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JOURNAL OF THE AERONAUTICAL SCIENCES

Volume 3 MARCH, 1936 Number 5

On the Stalling of Highly Tapered Wings

Presented at the Aerodynamics Session, Fourth Annual Meeting, I. Ae. S.

CLARK B. MILLIKAN, *California Institute of Technology*

INTRODUCTION

IN the last few years ever-increasing pressure has been exerted on designers to produce airplanes capable of carrying large payloads for long distances at high altitudes. In order to be successful, such airplanes must have very low parasite drag and very large equivalent monoplane span. The first requirement has led to the widespread adoption of the cantilever monoplane, for which the actual span must be large if the second requirement is to be satisfied. With large span cantilever monoplanes, the problem of wing weight is vitally important. One of the most attractive methods of reducing wing root bending moments, and hence wing weight, is to concentrate the lifting surface near the wing root which, for a wing of large span, implies a high taper ratio. If the wing area is to be kept within reasonable limits, such a wing will in general also have a high aspect ratio. The question of the aerodynamic characteristics of highly tapered, high aspect ratio wings is therefore one of great current interest. The behavior of such wings near the stall is especially important because of its effect on lateral stability and control. Unfortunately the phenomenon is so complex that no satisfactory theoretical discussion has yet been given, nor does it appear likely that such a discussion can be expected in the near future. Our knowledge must therefore be based on experiment. The present paper gives the results of measurements made at fairly large Reynolds Number in the California Institute of Technology (GALCIT) 10 ft. wind tunnel on two highly tapered wings. Its chief purpose is to indicate the nature of the phenomenon in question, and to suggest that a systematic and lengthy investigation will be required before safe predictions as to the behavior of a new design can be made.

TABLE 1

Geometrical Characteristics of Tapered Wings I and II. Both wings have straight taper from the center line, with the exception of elliptical tips.

	Wing I	Wing II
Taper Ratio.....	5–1	5–1
Aspect Ratio.....	8.9	11.06
Root Airfoil Section	NACA 23017	NACA 23020
Tip Airfoil Section.	NACA 23006	NACA 23012

EXPERIMENTAL OBSERVATIONS

The first data to be discussed were obtained from conventional force measurements on two tapered wings whose geometrical characteristics are given in Table 1.

These wings were originally tested in connection with model tests for the Douglas Aircraft Company, to which company the author makes grateful acknowledgment for permission to use the wings in his subsequent investigations and to include certain of the data from its tests in the present paper. The measurements discussed here were made at Reynolds Numbers based on mean chord between 1.2×10^6 and 1.5×10^6.

The results of the force measurements, reduced to normal coefficient form and corrected for wind tunnel interference, are presented in Fig. 1. In this figure have also been plotted for comparison corresponding curves for a rectangular wing of aspect ratio 6 and NACA 2412 profile. The rectangular wing tests were

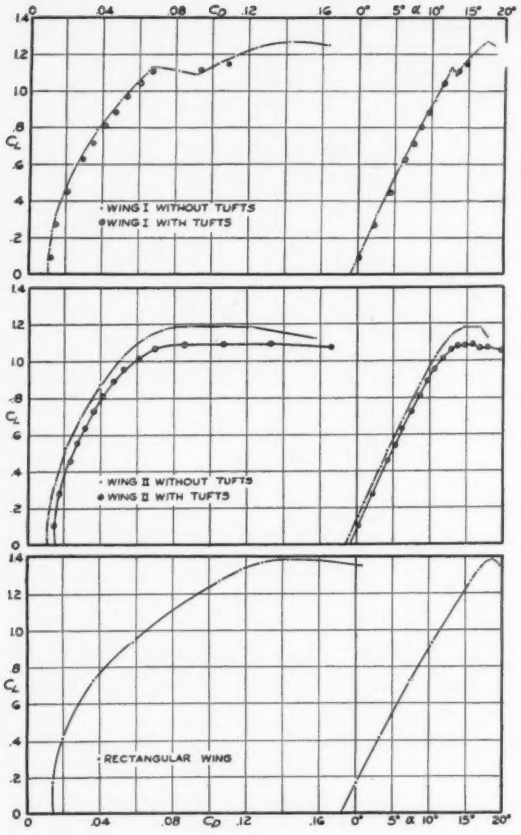


FIG. 1. Results of force measurements on two highly tapered wings and a rectangular wing.

made some years ago at the GALCIT, with turbulence introduced upstream from the model.[1] These curves are included only to indicate the nature of the phenomenon for a rectangular wing, and not for any quantitative comparison. For all three wings the points denoted by small dots correspond to conventional force measurements.

The extraordinarily sharp break in the curves for Wing I is very striking. When these curves were first plotted, it was felt that the break must have been the result of some error in measurement and a large number of check points was accordingly taken later. The complete consistency of these points with the earlier ones and with one another demonstrated that the phenomenon was a real one, and was in fact completely reproducible. On the other hand, the curves for Wing II, with the same taper but different aspect ratio and airfoil section distribution, show absolutely no such break, nor do the curves for the rectangular wing.

In order to investigate this curious behavior more closely, it was decided to observe the flow over the upper surfaces of the wings by the method of "tufts." The tufts were made of strands of fine silk floss arranged in a series of "U's" whose bases were attached to the wing surface by diagonal bands of very thin, transparent cellophane tape. The free ends of the U's were about $\frac{3}{8}$" long and acted as very responsive streamers in showing the direction and nature of the local velocity. Photographs of the wing were taken with a Leica camera held by hand just outside the wind tunnel. The intense illumination required was obtained from a battery of Photoflood lamps and an arc light. In order to reduce halation, the wing surface

[1] Clark B. Millikan and A. L. Klein, *The Effect of Turbulence; an Investigation of Maximum Lift Coefficient and Turbulence in Wind Tunnels and in Flight*, Aircraft Engineering, August, 1933.

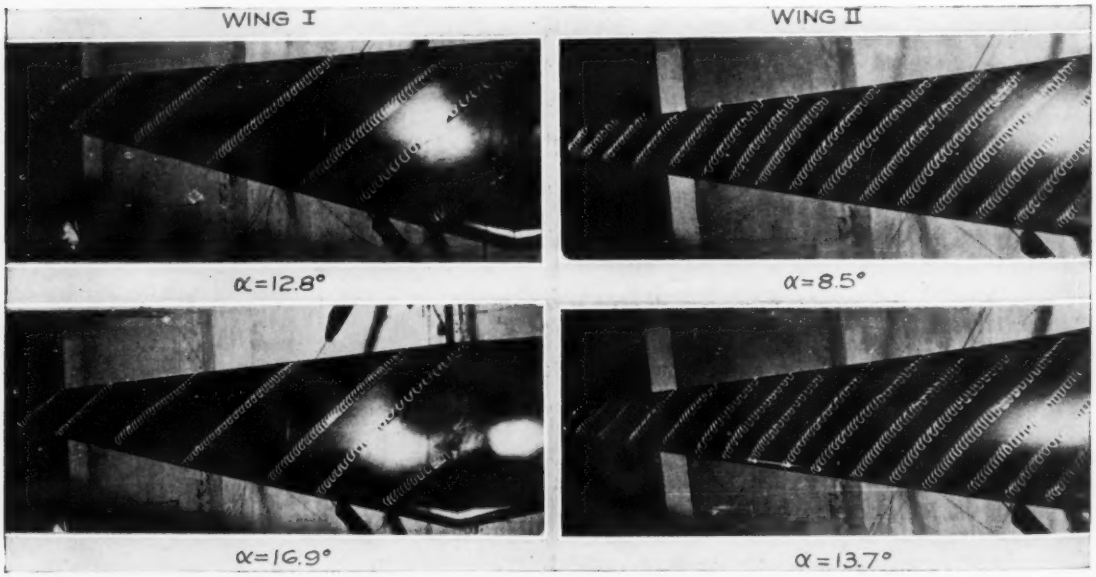


FIG. 2. Sample photographs of the tapered wings being investigated with tufts.

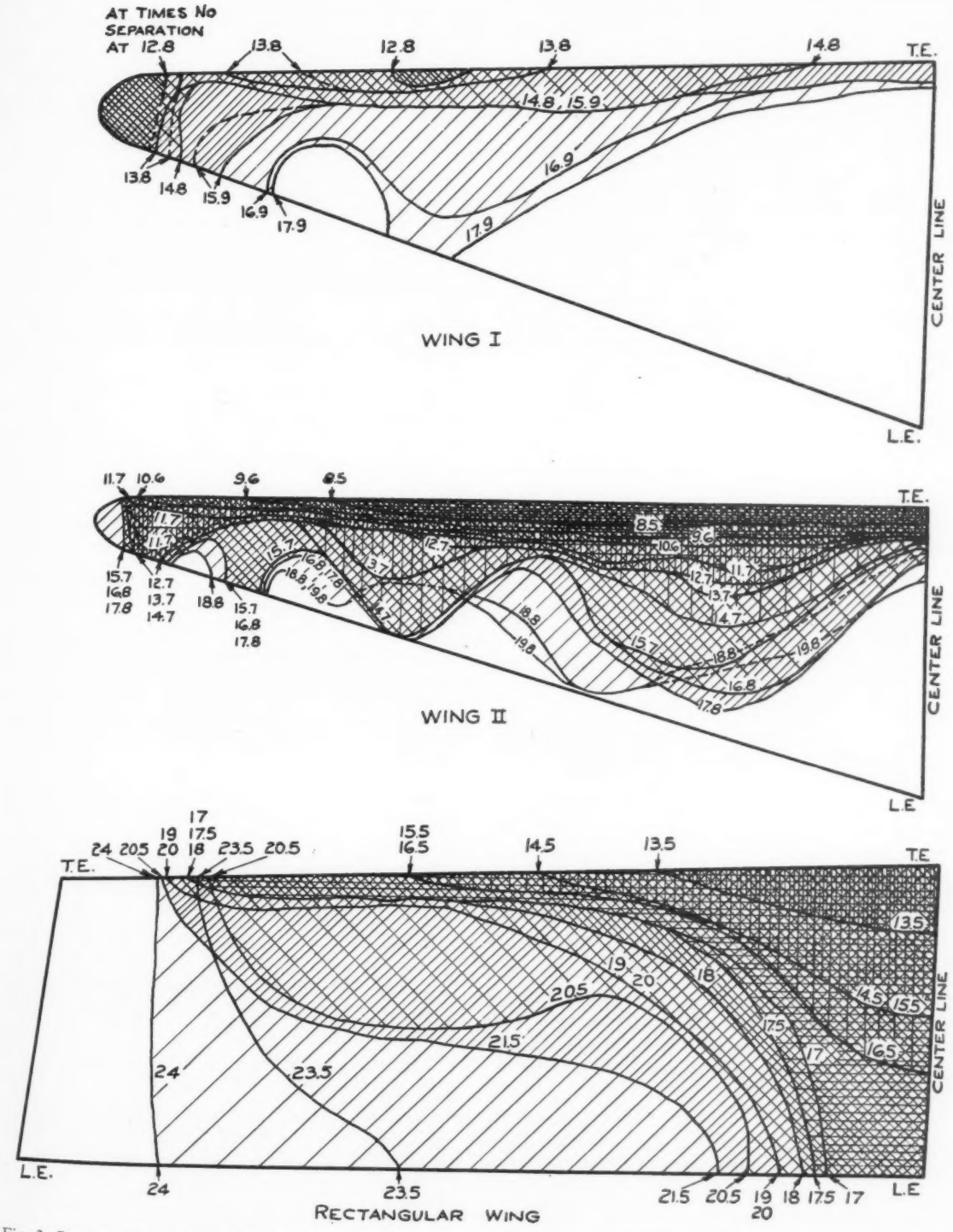


Fig. 3. Contours giving approximate lines of flow separation. Shaded areas correspond to a stalled condition, the depth of the shading being roughly proportional to the earliness of the stall. The numbers attached to the contours give the angles of attack at which the contours were observed.

was painted dead black, but even this did not eliminate the glare from all portions of the surface. The sample photographs of Fig. 2 show very clearly the fixed U portions of the silk floss filaments and the free tufts, although the cellophane strips are practically invisible. It should be noted that the plan forms shown in Fig. 3 are traced from enlargements of the photos. Due to perspective they are somewhat distorted, as is shown especially clearly in the case of the rectangular wing.

Photographs were taken at 1° intervals of angle of attack throughout the entire region in the neighborhood of the stall. All the photographs for one wing were then projected in succession onto a blank piece of paper and contours drawn free-hand along the approximate lines of flow separation. These were taken as the boundaries between regions where the tufts were steady, giving sharp images, and those where the former were clearly fluttering violently as revealed by fuzziness or even practical disappearance of the images. The exact interpretation of the state of the tufts and the consequent location of the contours is, of course, dependent to some extent on the judgment of the individual worker, but it is felt that the contours as drawn give a fairly correct picture of the actual flow conditions.

In Fig. 3 these separation contours are shown for the two tapered wings and for the rectangular wing. The pictures for the latter were taken several years previous to the present investigation, and were technically much less satisfactory than those for the tapered wings. In order to make the contour diagrams more clear, a set of shading lines has been drawn on the portion of the wing which was stalled at each angle. Those portions which stalled early are therefore heavily shaded, while those which stalled only when a large angle of attack had been reached are lightly shaded. The unshaded areas represent portions of the wing which remained unstalled at the largest angle of attack indicated on the contour lines. Several pictures were taken at each angle of attack, and in some cases the corresponding contours were not identical, indicating an instability in the flow pattern at the angle in question. For such cases the two limiting contours have been drawn, one being dotted. For Wing II at the two highest angles, certain portions of the wing which had previously been stalled became unstalled. The corresponding portions of these contours have also been plotted as dotted curves.

Force measurements were also made for the tapered wings with the tufts in place, the results being shown in Fig. I. (In the C_L vs. α plot for Wing I one of the experimental points with tufts has been omitted at the peak of the break in the curve. This was done so that the numerous and beautifully consistent points in this region for the smooth wing might be more clearly visible.) The force measurements with tufts were made in order to see whether the addition of the tufts appreciably altered the aerodynamic properties of the wings. For Wing I it appears that this was not the case, at least until above the break in the lift curves. Unfortunately the force measurements for this wing with tufts were not carried quite up to the complete stall, so that it is not entirely certain that the phenomena at the full stall were identical for the smooth and tufted configurations. For Wing II the lines of tufts were spaced much closer in an effort to define the separation contours somewhat more accurately. From Fig. 1 it appears that this had the effect of considerably modifying the wing characteristics. The drag is materially increased, the angle of zero lift shifted, and the peak of the lift curve flattened and lowered. However, the general nature of the flow phenomena with and without tufts should still be very similar, so that the contours of Fig. 2 should give a satisfactory qualitative picture even for the smooth wing.

Comparing Figs. 1 and 3 for Wing I it is quite clear that the sudden drop in lift at about 13° is associated with a sudden stalling of a small area at the wing tip. It is very remarkable that the stalling of so small a fraction of the wing area should lead to such a decrease in lift, while the slow creeping forward and in of the separation contour from 13° to 16°, with the consequent stalling of a much larger area, is associated with an increase in lift with angle at nearly the normal rate. The sudden jump forward of the separation contour, which with the tufts occurs at 17°, is almost certainly associated with the drop in lift to the right of the peak of the lift curve. The large region near the center of the wing which remains unstalled at the highest angles investigated is very noticeable. The curious unstalled "island" near the leading edge and about one-third of the distance in from the tip is very surprising, and no satisfactory explanation for its appearance has been found as yet. It will be observed that the same phenomenon in a somewhat modified form also occurs with Wing II. It should be mentioned in connection with the tip stall of Wing I that, although the tuft observations showed the flow configuration at the tip to be somewhat unstable in the neighborhood of 13°, the force tests were entirely reproducible. Measurements were made with α increasing and decreasing, and all of the points fell almost exactly on the broken curve as plotted, with no suggestion of a "hysteresis effect".

With Wing II the lift curve increases smoothly to the stall, and the separation contours have a somewhat different appearance. Separation appears all along the trailing edge at a fairly low angle and moves steadily forward until about 11° with no appreciable effect on the slope of the lift curve. At about 12° an instability appears, the separation contour jumping forward to the leading edge over a small region near, but not at, the tip. In this case, however, there is no indication of a drop in lift, but rather a smooth and continuous decrease in the slope of the lift curve. Above 12°

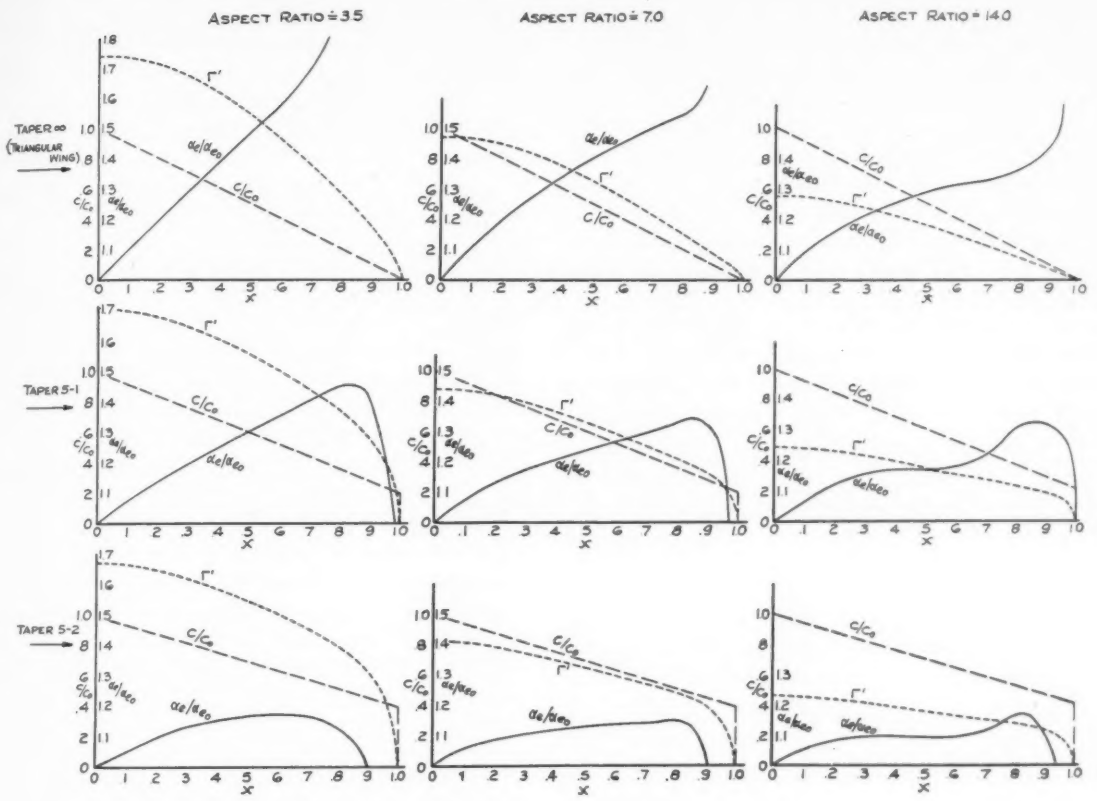


FIG. 4. Theoretical curves giving distribution of lift, chord, and effective angle of attack for a series of tapered wings.

the separation contour moves rapidly forward in a series of waves and the lift curve slope decreases until it becomes zero at about 15°. Above this angle the lift slowly decreases. From the lift curve for the smooth wing, it seems that without the tufts the rapid forward motion of the separation contour would be somewhat postponed and would finally occur even more rapidly than with the tufted wing, since the lift peak is sharper for the former case. The small tip area stalls only at 18°, i.e., above the angle for maximum lift of the main wing. One of the most curious features of the flow for this wing is that there are, in addition to the unstalled area near the center, three other "islands" near the leading edge which remain unstalled for some time after the areas around them have stalled.

For the rectangular wing the separation contours indicate a more familiar phenomenon. Separation begins at the trailing edge in the center of the wing. It spreads out along the trailing edge and forward at the center, having no appreciable effect on the slope of the lift curve until $\alpha = 17°$ or 18°. Above this angle the separation contour moves rapidly out towards the tip and the lift decreases. The tip remains unstalled until at least 6° above the angle for maximum lift of the wing as a whole.

DISCUSSION OF RESULTS

It is clear from the results with both Wings I and II that such highly tapered wings tend to stall first near the tip, and it appears that if the initial stall is sudden and just at the tip there may result a sharp premature drop in the lift. Nazir[2] has recently reported on an investigation of the stalling phenomena with tapered wings. His force curves show no premature break, and his flow pictures, obtained from eight tufts uniformly spaced along the semi-span at about mid-chord points, indicate a gradual and continuous spread of stalling in from tip to center. Unfortunately the Reynolds Number of his tests was so very small (apparently of the order of 5×10^4) that no satisfactory comparison with the present measurements or with free flight conditions could be expected). The two experiments are in agreement, however, with regard to the conclusion that stalling on a highly tapered wing begins near the tip earlier than at the center.

This effect has often been discussed before, usually as a result of theoretical investigations using the Prandtl wing theory. It is a consequence of the fact that the distribution of downwash over the span, resulting from

[2] P. P. Nazir, *Tapered Wing Stalling*, Jour. of Roy. Aero. Soc., Vol. XXXIX (1935), p. 750.

the trailing vortex configuration, is such that for an untwisted, highly tapered wing the effective angle of attack is larger near the tip than at the center. For a rectangular wing exactly the opposite is true.

In order to see whether the conventional wing theory might explain the difference in behavior of Wings I and II on the basis of the difference in aspect ratio, a series of tapered wings was investigated by this method. Fortunately in the Appendix to Fuchs-Hopf-Seewald[3] the results of an analysis of a systematic series of tapered wings are given. In Fig. 4 the distribution of chord and of circulation is replotted for certain of these wings. From these data the distribution of effective angle of attack was determined and plotted. The notation used in the figure is

Γ' is proportional to the circulation or lift per unit length along the span. No scale of ordinates is given for Γ' since the constant of proportionality is of no interest and was not determined.

c = wing chord.

α_e = effective angle of attack of a wing element, measured from the zero lift angle.

x = distance from center line of wing as a fraction of the semi-span.

$(\ )_o$ refers to conditions at the center of the span.

It should be pointed out that the wings discussed theoretically had tips squarely cut off while those investigated experimentally had rounded tips. Such rounded tips would tend to increase α_e/α_{e_0} very near to the tip but would probably not change the major portion of the α_e/α_{e_0} curves appreciably. The tendency for increasing taper ratio to increase α_e at the tip is very plain, but there is no suggestion that increasing the aspect ratio from 7 to 14 would materially decrease α_e/α_{e_0} at the tip, and so explain the difference between the characteristics of Wings I and II. A more elaborate theoretical investigation along the same lines seems hardly justified, since the flow near a wing tip is known to be three dimensional so that the validity in this region of any "first order" theory, such as that leading to Fig. 4, is very doubtful.

A possible explanation for the wings' different behaviors might lie in the much greater thickness of Wing II, especially at the tip. It appears that in order to really clear up the entire question of tapered wing stalling, it would be necessary to carry out a detailed experimental investigation, varying taper-ratio, aspect ratio, and airfoil thickness ratio systematically. The effects of deflected ailerons should also be investigated. Such an elaborate investigation could only be carried out by one of the great governmental laboratories, and it is hoped that this paper may serve in some small measure as a stimulus to the undertaking of such a research. Until such systematic tests are made, the only safe procedure for the designer of highly tapered wings would seem to be to have each individual wing design tested in a wind tunnel at fairly large Reynolds Number. Needless to say the use of a wing having a lift curve like that of Wing I would almost certainly be disastrous to lateral stability and control.

[3] Fuchs-Hopf-Seewald, *Aerodynamik*, Vol. II, Julius Springer, Berlin (1935).

The New Instrument Laboratory at the Massachusetts Institute of Technology

Presented at the Engines and Propellers Session, Fourth Annual Meeting, I. Ae. S.

C. S. DRAPER, *Massachusetts Institute of Technology*

INSTRUMENTS play an essential role in flight operations and in aeronautical research. The general field has become so important that a laboratory devoted entirely to instrument problems has been established at the Massachusetts Institute of Technology. This work was started some years ago in the Internal Combustion Engine Laboratory with the cooperation of Professors Edward S. Taylor and Charles F. Taylor. The new Laboratory has special equipment to study not only static calibrations, but also the manner in which instruments will respond to rapid changes in an actuating force. In each case a mechanical analogy is set up with the proper equivalent values of mass, elasticity and damping to represent the behaviour of a given instrument under operating conditions. These coefficients are determined from a record of instrument response to a sudden change in the actuating force. In order to check the agreement of theoretical predictions with experiment, special apparatus has been constructed which is designed for study of fundamental instrument problems rather than for routine test work. Several examples of this test apparatus are described below.

Recording Mechanical Model

It is not always possible to find simple mathematical expressions for the changes in actuating force to which an instrument is subjected in practice and, in any case, considerable labor is involved in the calculation of instrument response curves. These difficulties are overcome by means of a model mechanical system which automatically draws response curves for an arbitrary variation of actuating force. This arrangement has two carriages which roll on the same straight track. One of the carriages is forced to follow a wooden template shaped to represent the variation of actuating force with time while the other carries a pencil which draws a line on a sheet of paper moving with the template. The second carriage is connected to the first by means of a spring and a damping cylinder. Any system for which this arrangement is a proper model may be studied by selecting suitable sizes for the spring, the damping cylinder and the mass of the recording carriage.

Fig. 1 shows a diagram of the apparatus. Work is now in progress to extend the range of problems which can be handled, by the use of additional recording units in a modified design.

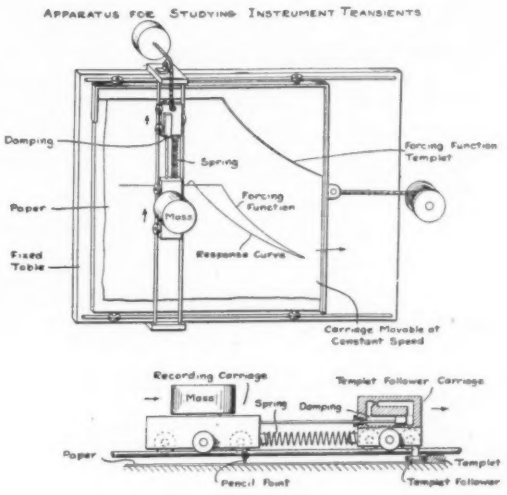


FIG. 1

Mechanical Vibration Apparatus

Mechanical vibration is often important in instrument work since an indicator must itself be insensitive to vibration or must be suspended in a properly insulated mounting. In order to analyze vibration problems into the simplest possible terms, a machine has been constructed for subjecting instruments to linear simple harmonic vibration. In this apparatus a spring loaded follower is forced to vibrate by a rotating eccentric driven from a variable speed electric motor. The instrument under tests is mounted on a carriage which reciprocates on ball bearing rollers along a straight track. The effect of vibration in different directions with respect to an instrument mechanism is found by means of a fitting which makes it possible to change the orientation of the instrument on the carriage. A diagram of the apparatus is shown in Fig. 2.

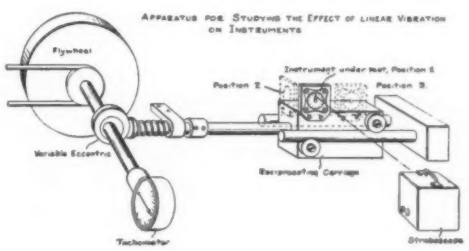


FIG. 2

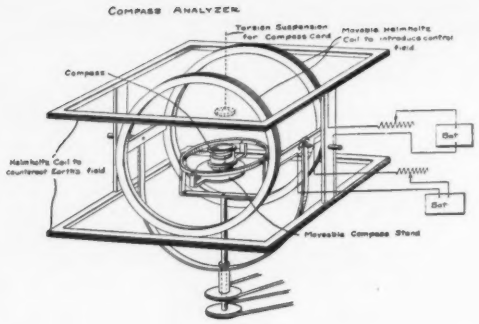


Fig. 3

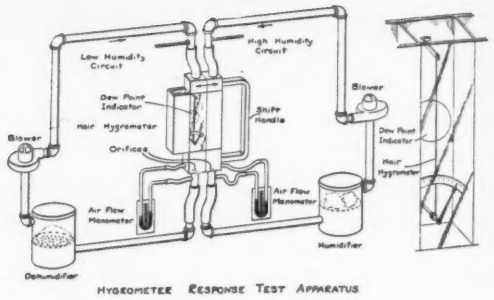


Fig. 4

The performance characteristics of instrument board shock absorber units can be studied by placing one of the units in the link which connects the eccentric with the carriage. By varying the weight on the carriage, the frequency, and the amplitude of the motion, all the necessary data can be found in a short time.

Compass Analyzer

The aircraft magnetic compass presents a complicated problem which is best attacked by an analysis of the forces and torques acting on the compass card into components referred to the principal axes of the card. The analysis is straight-forward but it is necessary to find experimentally the principal moments of inertia, the magnetic moment and the coefficients of viscous coupling between the compass liquid and the solid parts with which it is in contact. A "Compass Analyzer" has been built for the Laboratory with which the necessary data are easily obtained. This apparatus is based on an instrument developed by Walter McKay during his compass work at M. I. T. An outer Helmholtz Coil serves to balance out the earth's magnetic field over a region large enough for compass work. An inner Helmholtz Coil is mounted on a frame which may be rotated or oscillated in any desired manner. The compass itself is carried on a gimbal mounted stand which can be given an arbitrary motion independent of coil positions. Fig. 3 shows a diagram of the analyzer.

The inertial properties of the card are studied in the field free space at the centre of the outer coil by means of the calibrated torsional suspension indicated by dotted lines in Fig. 3. The free oscillation frequencies of the card measured in air and in the damping liquid supply the essential data on card properties. The magnetic moment is found from the change in period which occurs when a known magnetic field is applied by means of the inner loop. Viscous coupling effects are measured by observing the motion of the card which is produced by controlled movements of the field with the compass case stationary and by motion of the compass case with the field stationary.

Humidity Apparatus

In making accurate observations of temperature and humidity for meteorological purposes, it is necessary to make sure that lag effects in the indicators themselves do not introduce errors in the results. Apparatus for studying these lag effects is arranged to make a sudden known change in the quantity to which an instrument is sensitive. This result is accomplished by a rapid mechanical interchange of steady air currents which have differences in the property to be measured. Since ordinary precision instruments can be used to determine conditions in the two steady air streams, the method gives a very simple and convenient means for studying instrument characteristics.

Humidity indicators are investigated in an arrangement which has two closed circulating systems. In one of these systems a humidifier maintains a high humidity, while a chamber containing dehydrated calcium chloride reduces the humidity to a low value in the other system. A calibrated orifice and an alcohol manometer are used in each circuit to measure the air velocity produced by variable speed centrifugal blowers. Steady state humidity measurements are carried out by means of a dew point indicator located in the chamber which contains the instrument under test. Fig. 4 is a diagram of the humidity apparatus.

By means of the shift handle which changes the instrument chamber from one circuit to the other, the sensitive element can be subjected to a practically instantaneous change in temperature, air velocity, or humidity. The instrument response is recorded either by direct observation or with the aid of a motion picture camera. The humidity work is a continuation of a project started at M. I. T. by Athelstane F. Spilhaus.

Thermometer Lag Apparatus

Fig. 5 is a diagram of the apparatus used for studying response characteristics of bimetallic thermometer elements. A variable speed centrifugal blower supplies air to two identical closed air ducts. In one duct an energized electrical heating coil serves to raise the air temperature above that in the other channel. The

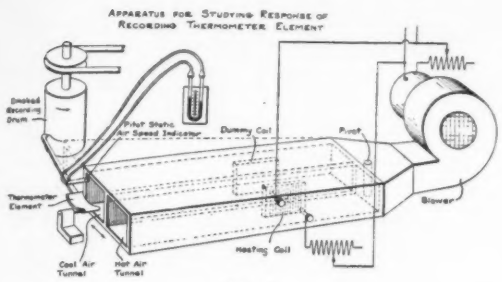


FIG. 5

air velocity at the open ends of the ducts is measured by means of a pitot-static tube and a sensitive manometer. An ordinary mercury thermometer is used to determine their temperatures. The long box which contains the ducts is pivoted at the end near the blower so that sidewise shift from the position shown in full lines to the position shown dotted in Fig. 5 will cause a sudden change in air temperature on the sensitive element. A stylus connected to the bimetallic strip is arranged to leave a trace on a smoked drum which rotates at a constant known speed. The time constant of the thermometer for a given air velocity is determined from an examination of the corresponding record.

Gyroscope Rotor Drive Apparatus

In order to produce quantitative results, the rotor of a gyroscopic rate of turn meter or turn integrator must rotate at a constant rate of speed under all

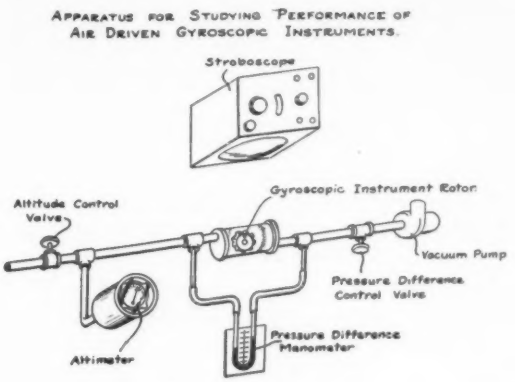


FIG. 6

flight conditions. It is thus important to study the variation in speed of an air driven instrument rotor with altitude and with pressure difference across the driving jet. Fig. 6 is a diagram of an arrangement for determining the effect of variations in operating conditions on rotor speed. An instrument with a glass window inserted in the side of the case is used so that the speed can be determined by means of a stroboscope. The pressure within the rotor chamber is controlled by a valve placed in the air intake to the system. An altimeter in a sealed chamber connected to the air inlet for the instrument indicates directly the altitude corresponding to the existing pressure. The pressure difference which drives the rotor can be adjusted by means of a valve in the line to the pump.

High Altitude Problems

Presented for Discussion at the High Altitude Problems Session, Fourth Annual Meeting, I. Ae. S.

MICHAEL E. GLUHAREFF, *Sikorsky Aircraft Division of United Aircraft Manufacturing Corporation*

THE time has arrived when not only airplane designers, but all progressive airline operators, are thinking of high altitude flying. The theoretical advantages of increasing speed with altitude, clear weather, no gusts of wind, no ice formation, etc., make the problem an interesting one indeed. All of these advantages warrant the study of the problem of high altitude flying, especially with the constant improving of the supercharging of engines.

At the stratosphere, for example, at an altitude of about 40,000 feet, a properly designed airplane of today may expect an increase in speed of about 50% to 60% over that at sea level for the same power expended.

No one disputes the many great advantages of such high altitude flying, but when the practical designer takes a pencil and slide rule, quite a number of difficulties spring at him from everywhere. In order to have a plan for study, in the opinion of the author, these problems in the order of their importance may be divided into five major groups, as follows: (1) The Power Plant, (2) Passenger Comfort, (3) Structural Problems, (4) Aerodynamics, and (5) Maintenance, Navigation and Operation. (This last item is not discussed because it is not of much importance to this particular paper.)

THE POWER PLANT

The Power Plant problem is purposely placed in the first group as this is the primary source of all possibilities of high altitude flight. The author does not know how many problems exist for this group because of the fact that it is not his direct specialty, however, he can foresee a few of them, for example:

(a) Cooling of the engines and oil. It appears that cooling depends on the density of the cooling medium and not from the velocity of the coolant.

(b) Ordinary fuel probably will boil in the tanks if there is not sufficient pressure present.

(c) Insulation of the electrical system should be different from that now used, due to low pressure. Batteries will have to be used instead of magnetos on the engines.

(d) The propellers will have to be specially designed. The critical tip speed velocity decreases with altitude, due to the temperature, which makes for lower efficiency. By decreasing the diameter, the angle of the blades gets too high for good efficiency. It is possible that propellers of four or more blades should be used, or several gear ratios on the engines or variable diameter propellers may be necessary.

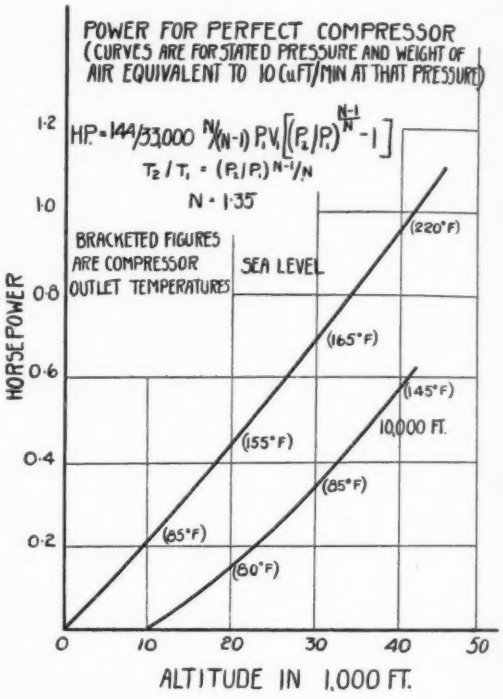


FIG. 1

(e) It is believed that supercharging of the engines is a big and separate problem. Being rather unfamiliar with this question, the author can not state exactly what the best supercharger type should be for use at the various altitudes, nevertheless, it seems that the turbo centrifugal supercharger is very attractive as the final fuel consumption depends a great deal on the method of supercharging selected.

PASSENGER COMFORT

The problems of this second group are as follows:

(a) The cabin must be supercharged, preferably to sea level condition, if the operator does not wish to lose time on climb and descent. At an altitude of 40,000 ft. maintaining the sea level pressure in the cabin with a circulation of twenty cubic feet of air per passenger per minute requires about 2.85 b.hp. if 70% efficiency is derived from the compressor. If it is desirable to maintain the pressure equal to 10,000 feet altitude with the same requirement of twenty cubic feet per minute per passenger, 1.7 b.hp. is required. (See Fig. 1.) It is probable that a centrifugal com-

pressor, or compressors for safety, can be procured which will be in line as far as weight is concerned.

Oxygen equipment can be used only to 20,000 ft. altitude unless sufficient pressure is present in the cabin. In case the oxygen is sprayed into the cabin at this altitude of 20,000 ft. and the oxygen content of the air is equal to the 10,000 ft. altitude condition, as appears to be the case when air is supplied at the rate of but 10 cubic feet per minute per passenger, it is necessary to deliver in the cabin 5200 cu. ft. of oxygen for 20 passengers during a period of 10 hours. Such equipment will weigh in the vicinity of 2500 lbs.

(b) A normal temperature must be maintained. At a 40,000 ft. altitude the air from the compressor will come to the cabin at plus 220° F., if the sea level pressure is maintained in the cabin, or plus 145° F. if the pressure maintained is equal to a 10,000 ft. altitude. (See Fig. 1.) Efficient cooling is required. At the same time, in the winter season, heat balance in the cabin must be maintained and a proper heating system will have to be installed. However, if the cabin is large it is not necessary to change all the air in a minutes time and a delivery of 20 cu. ft. per passenger per minute is quite satisfactory for comfort.

(c) Normal humidity not only is desired but is imperative. It does not seem that this problem should be difficult. On the contrary, it may save some energy assigned for cooling the incoming air from the compressors.

(d) Adequate Ventilation. This is probably a minor problem compared with the others, because in addition to the regular sea level ventilation as supplied, not much difficulty is expected when the cabin is supercharged.

It is very attractive to combine the Passenger Comfort Problems with the Power Plant Problems. Sufficient heat is available from the exhaust gases. The use of the steam boiler and turbine, if of proper design, might well furnish the power for all auxiliary equipment. Indications are apparent that this type of work is in progress in this country.

To supercharge the cabin and feed the engines with the air from the cabin, having no separate superchargers on the engines, is a very interesting proposition. The idea of boundary layer control of the fuselage may be applied by this means. The hypothetical airplane which the author studied for this paper is equipped with four engines of 2270 cubic inch capacity each. At cruising in this particular case, from 5,000 to 6,000 cu. ft. full weight of air per minute has to be supplied to the engine through the cabin. At 40,000 ft. altitude it will require approximately 715-860 b.hp., if seventy per cent efficiency of the compressor is again assumed. It seems that the compressors for such power will be too heavy and that there will be a strong draft in the cabin. Due to the fact that the power loading for altitude flying should be very light, as will be explained later, the power plant with its accessories may prove to be too heavy. The idea of the use of the steam engine with all its advantages of constant power at altitude, if it is properly designed, might be of great interest.

Structural Problems

The structural problems also are not small ones.

(a) The shape of the fuselage shall be cylindrical. The study of 11 by 37½ ft. cabins, both of round and of slightly oval shapes was undertaken. The cabin was supposed to be supercharged from 10,000 ft. to 25,000 ft. altitude. The computation revealed that for the slightly oval shaped fuselage, approximately 250 lbs. of additional weight was required to reinforce the frames to overcome the bending stresses due to uneven expansion. For 40,000 ft. altitude, the weight increase will be about twice this figure. The thickness of the skin, in general, is not prohibitive. As a matter of fact, the pressure in the fuselage gives additional stability to the structure.

(b) The doors, windows and hatches have to be small and very strong. For example, at an altitude of 40,000 ft. the small door of 5 by 2 ft. must withstand a constant negative pressure of 17,200 lbs. Heavy locks and hinges must be used. The pilot's cockpit presents quite a problem, and it appears that it will be necessary to supply a double windshield.

(c) Controls have to be electrically or hydraulically transmitted to the surfaces as it would be close to impossible to use direct controls due to inevitable leakage. However, from the structural standpoint, the problems are not unsurmountable, but represent a considerable increase in weight over that of the conventional airplane. One point will be interesting to ascertain. That is, how the low pressure and low temperature effect the crystallizing processing of metal.

Aerodynamics

The aerodynamics of an airplane for high altitude flight must be studied very carefully due to the fact that more efficiency may be expected by properly designing the plane. The wing profile has to be chosen in connection with the wing loading and a proper high lift device selected, if high wing loading is adopted.

A very brief and general study of six hypothetical airplanes of the same gross weight of 40,000 lbs. was undertaken. The same power loading of 8.35 was assumed as was the same propeller efficiency of .835. The difference is in the cleanliness of design; one is a NORMAL airplane with the engine in the leading edge, the other one a CLEAN one with the engine enclosed in the wing, both with aspect ratios of six and ten and both with wing loading of twenty and thirty-three pounds per square foot. For the sake of simplicity and abstract study, these hypothetical airplanes were assumed to be of the same ideal weight empty of 25,000 lbs., with moderate allowance included for passenger

TABLE I

GROSS WEIGHT	40,000 lbs.
WEIGHT EMPTY	25,000 lbs.
WING AREA	1220 SQ.FT & 2000 SQ.FT
POWER 4800 BHP.	PROP. EFF. 0·835

CRUISING PERFORMANCE
IN M.P.H.

W/S	% BHP	NORMAL A.R. 6	NORMAL AR 10	CLEAN AR 6	CLEAN AR 10	W/b² AR 6	W/b² AR 10	ALTITUDE
20	50	186	189	205	209			
	70	210	213	233	236	3·32	2.00	SEA LEVEL
33	50	192	198	218	224			
	70	220	224	246	254	5·45	3·32	
20	50	223	230	246	254			
	70	254	260	282	289			20,000'
33	50	227	238	258	268			
	70	266	272	303	310			
20	50	274	291	305	324			
	70	324	333	360	371			40,000
33	50		285	301	349			
	70	327	341	377	396			
PERCENTAGE INCREASE OF GROUND SPEED								
20	50	19·5	22·0	20·0	21·5			0 FT
	70	21·0	22·0	20·5	22·0			TO
33	50	18·0	20·5	18·0	20·0			20,000
	70	21·0	21·0	22·0	27·0			
20	50	47·0	53·5	49·0	55·0			0 FT
	70	54·0	55·5	54·0	57·0			TO
33	50	25·0	44·0	37·5	55·0			40,000
	70	48·0	52·0	53·0	62·0			

equipment, but without any special high altitude equipment whatsoever.

Resistance of the component parts of the airplane was assumed rather optimistically and as the same in all cases, namely:

1. Engines (when exposed) D_c =.16
2. Tail (constant area for all airplanes) =.3 lb./sq. ft. at 100 m.p.h.
3. Wings (minimum D_F) =.008
4. Fuselage =2 lbs./sq. ft. at 100 m.p.h.

The size of the cabin, 11 by 37½ ft., was the same for all airplanes. This cabin was assumed to be sufficiently comfortable for the sleeping accommodations for twenty passengers.

From Table I it may be seen that while cruising at 50% power the speed varies, depending on the above mentioned factors of design, from 186 to 224 m.p.h. at sea level. At 20,000 ft. altitude it varies from 223 m.p.h. to 268 m.p.h. and at 40,000 ft. from 270 m.p.h. to 349 m.p.h. When cruising at 70% power, the speeds vary in approximately the same ratio, being, for the best airplane, 254 m.p.h. at sea level, 310 m.p.h. at 20,000 ft. altitude, and 396 m.p.h. at 40,000 ft. altitude.

By studying this particular table, it appears that cleanliness of design is the most important factor. The second factor, and not much less in importance, is the aspect ratio, particularly for lower power cruising. The third factor is the heavy wing loading in combination with the high aspect ratio.

Figs. 2 to 5 give the variation of the aspect ratio and wing loading, are based on the same hypothetical airplanes, and deal with the speed close to the best L/D and somewhat higher ones. From these curves, it may be concluded that in these particular airplanes, disregarding the altitude at which they are flying at best L/D, the governing factor is high aspect ratio while the wing loading is not of great importance. For flying at a somewhat higher speed, the high aspect ratio and the heavy wing loading are of equal importance.

TABLE II

2000 MILE RANGE

FUEL CONSUMPTION 0·48 lbs/BHP-hr

W/S	% BHP	NORMAL A.R. 6 FUEL IN POUNDS	NORMAL A.R. 6 HOURS OF FLIGHT	NORMAL AR 10 FUEL IN POUNDS	NORMAL AR 10 HOURS OF FLIGHT	CLEAN A.R. 6 FUEL IN POUNDS	CLEAN A.R. 6 HOURS OF FLIGHT	CLEAN AR. 10 FUEL IN POUNDS	CLEAN AR. 10 HOURS OF FLIGHT	ALTITUDE
20	50	10,300	10·75	10,120	10·55	9,360	9·75	9,160	9·55	
20	70	12,600	9·52	12,600	9·36	11,530	8·58	11,400	8·47	SEA LEVEL
33	50	10,000	10·40	9,700	10·10	8,800	9·17	8,570	8·93	
33	70	12,100	9·09	12,000	8·94	10,920	8·13	10,600	7·87	
20	50	9,250	9·65	9,060	9·45	8,500	8·85	8,220	8·55	
20	70	11,500	8·55	11,100	8·25	10,400	7·75	10,150	7·53	20,000
33	50	9,160	9·55	9,040	9·40	8,110	8·45	7830	8·15	
33	70	11,100	8·25	10,800	8·05	9,700	7·20	9500	7·05	
20	50	8,400	8·75	7,400	7·70	7,100	7·38	6,730	7·00	
20	70	9,400	7·00	9,150	6·80	8,500	6·34	8,300	6·16	40,000
33	50			7,600	7·90	7,200	7·50	6250	6·50	
33	70	9,300	6·92	8,950	6·65	8,200	6·10	7,800	5·80	

TABLE III

TABLE OF COMPARISON

GROSS GAIN IN FLYING AT ALTITUDE FOR 2000 MILE RANGE

BY CHOOSING THE BEST OUT OF SIX HYPERTHETICAL AIRPLANES THE FOLLOWING ECONOMY CAN BE OBTAINED AT ALTITUDE

ALTITUDE	SAVING OF FUEL IN lbs	SAVING OF TIME IN HRS
	CRUISING AT 70% POWER	
20,000	720	0·78
40,000	2320	2·43
	CRUISING AT 70% POWER	
20,000	1,100	0·82
40,000	2,800	2·07
	CRUISING AT 44% POWER BEST L/D	
40,000	4,000	0·37

In Table II climb and power gliding are taken into consideration, with the assumption of constant climb and descent at the rate of 400 ft. per minute. A conclusion may be drawn as to which is the preferable design by comparing the duration of flight and weight of the actual fuel necessary for the given range at various altitudes and power.

Table III, which takes the most efficient of the studied airplanes, shows that when cruising at 50% power at 40,000 ft. altitude, there is a saving of 2,320 lbs. in fuel and 2.43 hours in time, as compared with sea level flying at the same power. At 70% power at 40,000 ft. altitude, we save 2,800 lbs. of fuel and 2 hours in time, as compared with the same power at sea level. The greatest advantages of 40,000 ft. altitude flying is that we can maintain the same time schedule as at sea level cruising at 70% of the power by the use of but 44% of the power at the 40,000 ft. altitude and still save 4,000 lbs. of fuel.

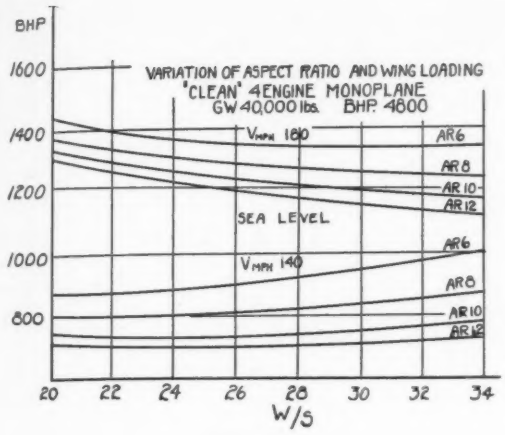


FIG. 2

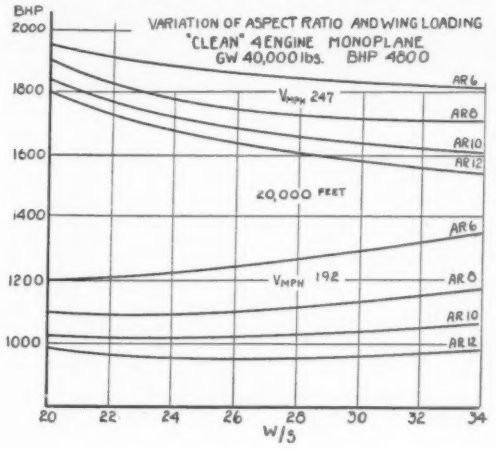


FIG. 4

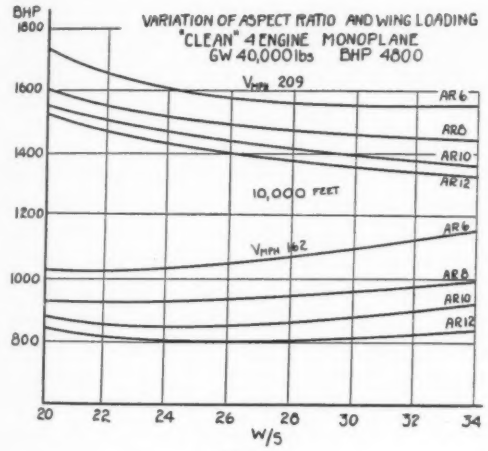


FIG. 3

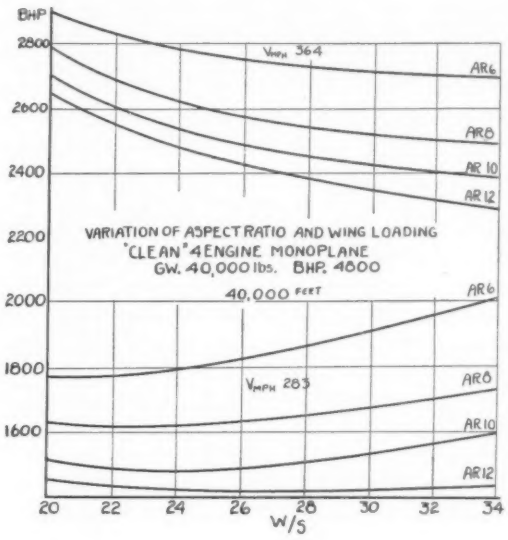


FIG. 5

At this point, it is well to remember that power loading must be small in order to get constant maximum permissible climb to the desired cruising altitude and allow sufficient power to travel at the best L/D at this altitude. We reach the conclusion that the final and maximum saving in weight of fuel we have is exactly 10% of the Gross Weight. The question arises as to whether it is possible to procure the necessary altitude equipment low enough in weight to justify building such an airplane. At the present time it appears to the author that the equipment and structure cannot be produced within such a weight allowance, although it is possible that the picture may change in the near future when more studying and experimentation have been done on the subject. Flying in the stratosphere, even when all problems are solved, will still be practical for very long distances only if sea level pressure in the cabin is maintained. Even for a 2,000-mile range, it is necessary to use approximately 35% of the distance for climb and descent. For a 700-mile range, practically the entire distance is required for the climb and descent.

When the exact direction and velocities of the constant winds in the stratosphere shall be known, it will be possible to operate the "one-way" airplane by taking advantage of the westerly winds which in the region of the stratosphere are probably as strong as 90 to 100 m.p.h. Due to the tremendous difficulties in the various problems, long and extensive study will be required before the building of an experimental airplane can be undertaken. There is not sufficient assurance today that commercial stratosphere airplanes can be built and operated successfully.

An Electrical Device for Solving the Equations of Longitudinal Stability

Presented at the Aerodynamics Session, Fourth Annual Meeting, I. Ae. S.

R. K. MUELLER, *Massachusetts Institute of Technology*

THE longitudinal motion of the airplane can be represented to a first approximation by the solution of a set of three simultaneous differential equations. The form of these has been well known for many years, but they have been assimilated into the practical technique of airplane design very slowly. This reluctance of designers to avail themselves of the only theory which even remotely agrees with fact is natural enough because of the difficulty in carrying out correct solutions. In view of this, the disinclination of designers to stake too much upon a kind of mathematical accuracy which has frequent lapses in all of us is quite proper. However, if this reason could be removed, the basis of judgment could be shifted to the actual merit of the theoretical approach where it really belongs.

The subject of this paper is a calculating machine which is intended to do just this. While it requires that certain preliminary calculations be made in the usual way, the actual determination of the period and damping of the motion is accomplished almost instantly and with no chance of serious mathematical inaccuracy. Calculating machines are all based upon physical phenomena which can be expressed mathematically. While commonly the equation is regarded as the key to the phenomenon, in the machine the opposite is the case. For this it is necessary that the answer may be found by means other than direct solution, that is, by some kind of measurement. If the equation is correct, the measured solution must automatically satisfy it. The machine for solving the Equations of Longitudinal Stability uses a system of electrical elements. These are put together and rendered capable of adjustment so that the equations which indicate the behavior of various electrical currents with time may be made to look exactly like the Stability Equations, except for changes in scale. In a sense we have an extremely flexible, ficticious airplane in the electrical realm which can be warped into coincidence with most conventional types by turning a few knobs. Its equations being identical with those for the real airplane are, of course, no easier to solve, but fortunately there is no need to solve them because the answers can be measured directly by suitable instruments.

The construction of the electrical system depends upon the fact that a charge moving through a circuit can be made to experience forces depending upon its motion which are like mechanical inertia and aerodynamic force. The analogy has been carried out consistently by the use of resistors, condensers, and vacuum tubes. A reduction in time scale of about 5000 has been made. There has been no serious attempt to attain high accuracy, but the answers measured from the present model check quite closely with the calculated ones. This model has been made to cover only the case of motion after a disturbance with locked controls, but it can be extended to include gyroscopic control of the elevators with or without phase change quite easily. For a disturbance, we have chosen one which is comparable to that experienced by an airplane flying in still air into an approaching gust. This was selected more because it gives a result readily compared with the calculated one than for any natural reasons. More general types of disturbance whose effect is practically hopeless to find mathematically are allowable. The machine is quite indifferent and will react as well to one kind as to another.

In order to give some idea of the manner of operation of this machine as well as to illustrate the effect upon airplane stability of a few typical design variations, we have prepared a group of examples. The basic aerodynamic data for all of these has been taken from a design of a 4 passenger monoplane having a top speed of about 158 m.p.h. Its exact details are not important for these purposes. In the calculations at different speeds and flight attitudes we shall neglect the effect of propeller thrust and slipstream variations as these, though important, tend to obscure certain basic trends of stability in flight with power off.

(1) The first example (Fig. 1) shows the character of motion after a fixed disturbance at cruising speed (140 m.p.h.) and at a relatively high angle of attack corresponding to about 67 m.p.h. The tendency of the period to shorten at the lower speed is typical of all conventional airplanes. Because of the presence of the factor τ which is inversely proportional to speed and therefore larger at lower speed, the shortening of period is less than would appear from the electrical solution. Actually the times are about 35 seconds and 17 seconds.

(2) Since airplanes of different sizes often look alike, the effect of size with constant wing loading is interesting (Fig. 2). We shall show the results, at the same high angle as above, of halving and doubling the size as originally given. The motions as found electrically are comparable except for amplitude, since the quantity τ is unchanged. However, the amplitudes are not comparable because the disturbance is proportional to the size. By halving the amplitude for the

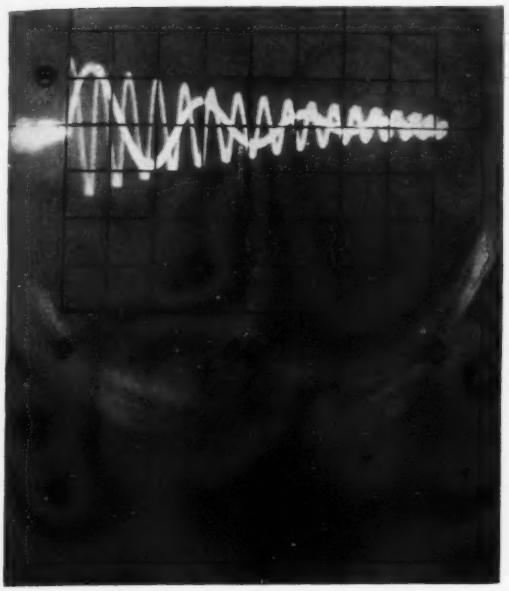


FIG. 1. High and low angle of attack.

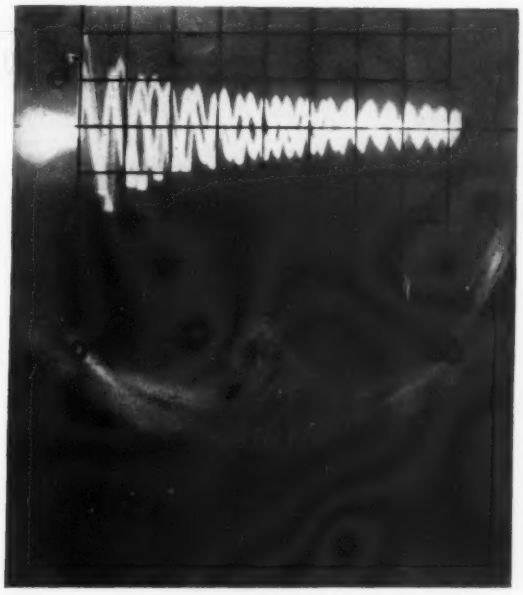


FIG. 2. Different values of $\mu = m/(\rho sl/2)$, at high angle.

large airplane and doubling that for the small one the results are completely comparable. This correction is necessary because the equations around which the electrical analogue has been designed are a dimensionless set. The final result, (Fig. 3a), shows that the larger airplane is better damped and less violently affected by at least one kind of atmospheric disturbance.

(3) A design tendency is the increase of wing loading. Although this has been accompanied by other changes so that the general appearance of the typical airplane has changed somewhat, we can roughly indicate the general result of this trend by considering three airplanes identical in size, appearance, and weight distribution, but powered and loaded in the ratio 1:2:4. Again overlooking the variations normally introduced by power on, structural practice, and differences in speed corresponding to the same attitude, the respective motions at the same high angle may be found from the same set of curves as for example (2). The heavier airplane appears to be more poorly damped as was the smaller one above. When applied to this example the curves have correct amplitude but incorrect time relationship, just opposite to their previous application. When adjustment is made, (Fig. 3b), it is found that damping of the heavier airplane is even worse than it appears at first sight and its period somewhat longer. Incidentally all the effects of an increase in wing loading are encountered for a decrease in air density in the same proportion with no change in wing loading. Thus, after a given disturbance the heavy or high-altitude airplane has a motion like the small one except that it pursues this less rapidly and with smaller amplitude, and the tendency in all cases is toward poorer damping.

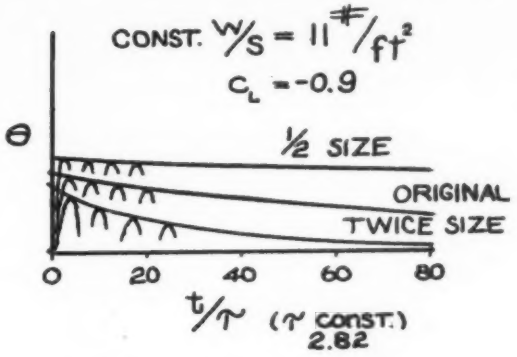


FIG. 3a. Change in size at high angle.

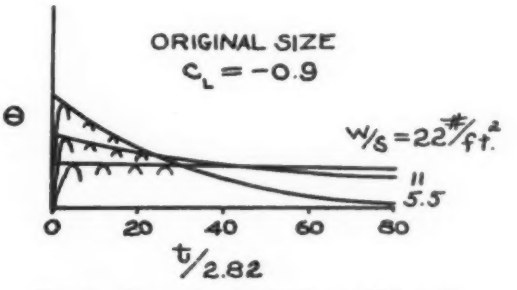


FIG. 3b. Change in wing loading at high angle.

(4) A final example shows the effect of what may be considered a more genuine design variation in the sense that it alters the appearance of the airplane. This consists in holding the ratio between the static pitching moment and damping moment coefficients constant while changing their magnitude. Such a change is produced fairly closely if the tail area alone is varied. A more precise adjustment requires a slight shift in

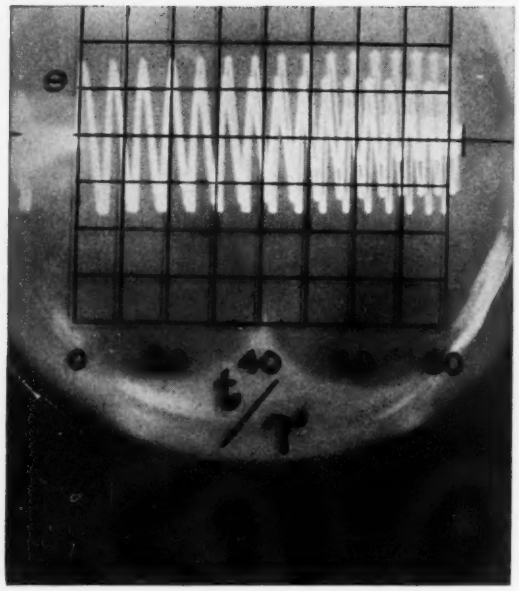


FIG. 4. Different values of m_w with m_w/m_q held constant.

C. G. location. Holding this ratio at 1:2, about where it lies for the original design, we find a set of curves, (Fig. 4), which show very little variation in period but considerable in damping at the high angle of attack. For a tail area about ½ the original there is no tendency to subside at all and smaller areas produce a divergence.

It should be emphasized that these examples merely demonstrate a method and by no means exhaust it. The method can be extended to the Equations of Lateral Stability with or without control, without radical change. Even a lengthening of the time scale to that of the actual airplane may be possible, although the difficulties are formidable. This would allow the use of a hand-operated control system and perhaps the methodical investigation of trained and untrained pilot reaction for various airplanes under various conditions. It is well to recall that all small-scale aerodynamic test data result from substitution measurement and that the principle is not an untried one. The equivalences between an airplane and its reduced scale model, and the airplane and its electrical analogue differ in kind but not in essence.

TABLE OF COEFFICIENTS

Example	*Variation*	c_1	μ	τ	x_u	x_w	μc_1	z_u	z_w	m_u	m_w	m_q
1....	Original.....	—.22	13.6	1.39	—.05	+.126	—3.00	—.44	—4.5	0	—3.72	—7.49
	Original.....	—.9	13.6	2.82	—.115	+.515	—12.2	—1.8	—4.5	0	—3.72	—7.49
2....	Twice size.....	—.9	6.8	2.82	—.115	+.515	— 6.1	—1.8	—4.5	0	—3.72	—7.49
	Original size.....	—.9	13.6	2.82	—.115	+.515	—12.2	—1.8	—4.5	0	—3.72	—7.49
	Half size.....	—.9	27.2	2.82	—.115	+.515	—24.4	—1.8	—4.5	0	—3.72	—7.49
3....	Twice weight.....	—.9	27.2	4.00	—.115	+.515	—24.4	—1.8	—4.5	0	—3.72	—7.49
	Original weight....	—.9	13.6	2.82	—.115	+.515	—12.2	—1.8	—4.5	0	—3.72	—7.49
	Half weight.....	—.9	6.8	2.00	—.115	+.515	— 6.1	—1.8	—4.5	0	—3.72	—7.49
4....	Different m_w's.....	—.9	13.6	2.82	—.115	+.515	—12.2	—1.8	—4.5	0	— 3.0	— 6.0
	with constant.....	—.9	13.6	2.82	—.115	+.515	—12.2	—1.8	—4.5	0	— 2.0	— 4.0
	ratio $m_w/m_q = ½$.	—.9	13.6	2.82	—.115	+.515	—12.2	—1.8	—4.5	0	— 1.5	— 3.0

Span Load Distribution on a Tapered Wing as Affected by Partial-Span Flaps from Tests in the Full-Scale Tunnel

Presented at the Aerodynamics Session, Fourth Annual Meeting, I. Ae. S.

JOHN F. PARSONS, *National Advisory Committee for Aeronautics*

SUMMARY

Pressure-distribution tests were made in the N. A. C. A. full-scale wind tunnel upon a 2:1 tapered U. S. A. 45 airfoil equipped with 20 percent chord split trailing-edge flaps of various spans. The results were obtained at an approximate Reynolds Number of 3,800,000. The data have been analyzed particularly with regard to the effect of flap span upon span load distribution, lateral center-of-pressure location, and the effectiveness of extending the flap span.

The test results show that the lateral center-of-pressure location moves outboard with an increase in flap span for all angles of attack and flap angles investigated. The normal-force coefficient is increased only slightly by extending the span of a split flap beyond 70 percent of the wing span.

In additional to the experimental data, two methods of theoretical analysis are presented in an attempt to generalize the experimental results. For all conditions of test, a satisfactory approximation of the experimental span load distribution for an airfoil-flap combination may be obtained by adding to the loading for the plain airfoil the increment of load due to flap deflection as computed by the Lotz method. A method less tedious than the Lotz method of computing the span load diagrams for an airfoil-flap combination is one assuming the flap to be replaced by a simple U-vortex trailing from the flap tips. This method affords a fair approximation to the experimental results for short partial-span flaps at small flap deflections.

INTRODUCTION

A COMPLETE knowledge of the aerodynamic properties of a wing equipped with flaps is prerequisite to an accurate structural analysis and design of the combination. Numerous researches have provided an abundant amount of detailed information upon the section characteristics of flap-equipped airfoils; however, reliable experimental information regarding the load distribution along the span of an airfoil equipped with flaps is lacking.

The investigation reported herein was conducted to provide information upon the span loading of a tapered wing equipped with a split flap. The included data are the results of pressure measurements made along the span of a 2:1 tapered U. S. A. 45 airfoil tested in combination with three sets of split trailing-edge flaps of various spans, each set at two flap angles. In view of the lack of information of this nature an attempt has been made to generalize the experimental data presented by comparison with a theoretical analysis.

APPARATUS

A half-span airfoil in conjunction with a reflection plane was used in the investigation (Fig. 1). The full-span tapered U. S. A. 45 airfoil, thus simulated, has

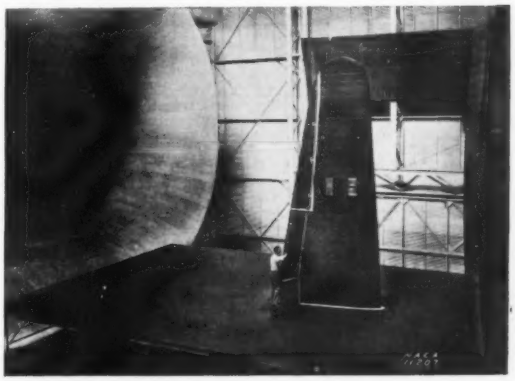


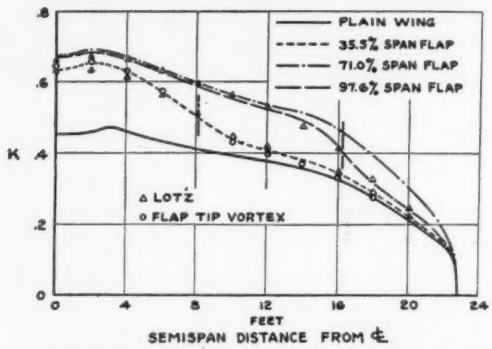
FIG. 1. Half-span tapered U.S.A. 45 airfoil equipped with 20 per cent chord and 35.5 per cent span split flap.

a span of 45.75 feet, an aspect ratio of 6.20, a mean chord of 7.38 feet, and an area of 337.5 square feet. The airfoil has an 18 percent thick constant-chord center section extending 10.7 percent of the span from the plane of symmetry. The airfoil has circular tips and from the center section outboard tapers 2:1 both in thickness and plan form. The plywood split trailing-edge flaps were hinged at 80 percent of the wing chord and a flap chord to wing chord ratio of 0.2 was maintained throughout the flap span. Three flap spans, 35.5, 71.0, and 97.6 percent of the wing span, were fitted to the airfoil. Pressure orifices were installed in nine pressure ribs located along the span. The pressures at these orifices were measured by two multitube recording manometers. The half-span portion of the airfoil-flap combination was mounted vertically above the reflection plane which was tangent to the lower surface of the wind-tunnel entrance cone. The tests were conducted in the N. A. C. A. full-scale wind tunnel.

TESTS

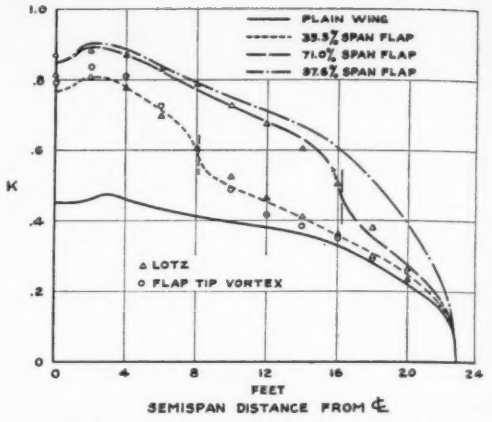
To justify confidence in the reflection plane method of testing, preliminary tests of the plain airfoil were made to afford a comparison with previous full-span airfoil tests. The comparison showed the results of the two tests to be in excellent agreement.

Pressure measurements were made upon the airfoil-flap combination with the three spans of flap, each set at two flap angles, 20° and 60.° The tests were made at several angles of attack throughout the normal flight range and at an approximate Reynolds Number of 3,800,000.



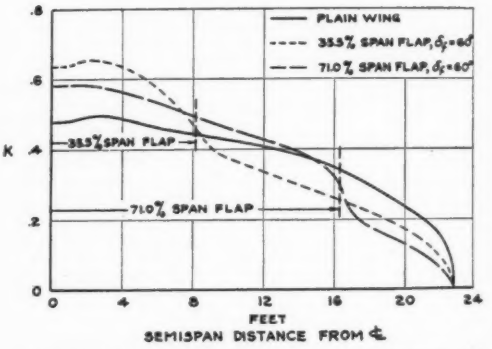
SEMISPAN LOAD DIAGRAM, 2:1 TAPERED U.S.A. 45 AIRFOIL WITH 20% CHORD PARTIAL SPAN SPLIT FLAPS, $\delta_f = 20°$, $\alpha = 10°$

FIG. 2



SEMISPAN LOAD DIAGRAM, 2:1 TAPERED U.S.A. 45 AIRFOIL WITH 20% CHORD PARTIAL SPAN SPLIT FLAPS, $\delta_f = 60°$, $\alpha = 10°$

FIG. 3



SEMISPAN LOAD DIAGRAM, 2:1 TAPERED U.S.A. 45 AIRFOIL WITH 20% CHORD PARTIAL SPAN SPLIT FLAPS, $\delta_f = 60°$, $C_N = 1.2$

FIG. 4

RESULTS AND DISCUSSION

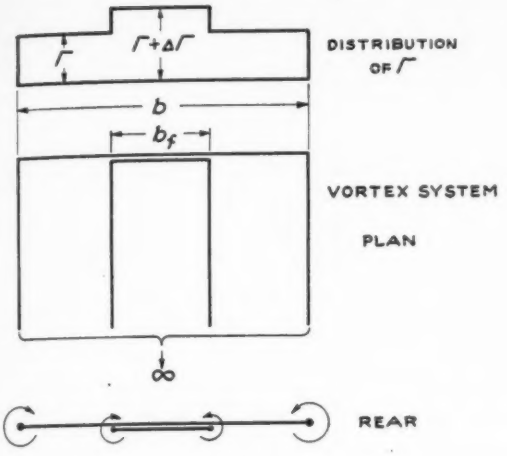
This paper presents the results of the pressure measurements in the form of semispan load diagrams, lateral center-of-pressure locations, and the effectiveness of added increments of flap span.

Plots of the relative normal loadings K against the semispan are shown in Fig. 2 ($\delta_f = 20°$) and Fig. 3 ($\delta_f = 60°$) for an angle of attack of 10°. These typical semispan load diagrams are for the plain airfoil and for the combination with the three sets of flaps. The arbitrary coefficient K is defined as $c_n \times$ section chord/semispan, in which c_n is the section normal-force coefficient. As would be expected a decided similarity is noticeable between the semispan load diagrams for the plain airfoil and for the 97.6 percent or full-span flap combination. The ratio of the loadings, at all points along the semispan, is approximately equal to the ratio of the respective normal-force coefficients for the two conditions. Likewise anticipated is the abrupt drop in loading at the partial-span flap tips and the mutual effect of the "flapped" and "unflapped" portions of the combination each upon the other.

Fig. 4 presents, at a constant normal-force coefficient of 1.20, semispan load diagrams for the plain airfoil and for the combination with the partial-span flaps deflected 60.° The diagram for the full-span flap combination, being practically identical with that for the plain airfoil, has been omitted from the figure. The diagrams indicate the effect of the partial-span flaps showing the abrupt break in loading at the flap tip and the resultant distribution as compared with the plain wing loading. It may be noted that the diagrams for the combination with the partial-span flaps cross the plain wing loading curve at approximately the flap tip. The loading outboard of the flap tip is decreased (an equal increase inboard) from the plain wing loading by approximately 12 percent for the smaller partial-span flap combination and 8 percent for the larger.

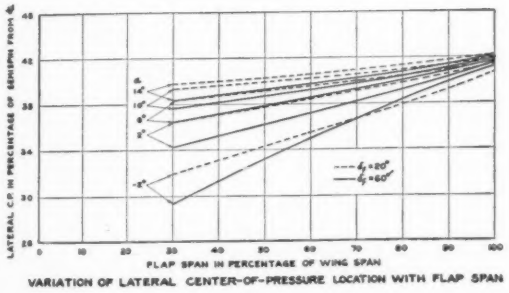
In view of the lack of prior experimental research on this subject, the presented data are of an isolated nature and generalization is unwarranted unless a theoretical analysis provides a sufficiently accurate check upon the experimental results. In an attempt to approximate the experimental span load diagrams obtained for the partial-span flap combinations, two methods dependent upon aerodynamic theory have been used.

One method which suggests itself because of its elementary nature, although it is at best a first approximation of the actual flow conditions, is the substitution of a simple vortex system for the partial-span flap. Two initial or basic conditions of loading are involved dependent upon the portion of the loading curve considered. These basic loadings are, for the flapped and unflapped portions of the airfoil-flap combination, respectively the section loadings for the full-span flap and airfoil without flap conditions. The circulation strength of the U-vortex assumed trailing from the flap tips (Fig. 5) is equal to the increase in circulation over that of the plain airfoil. From the



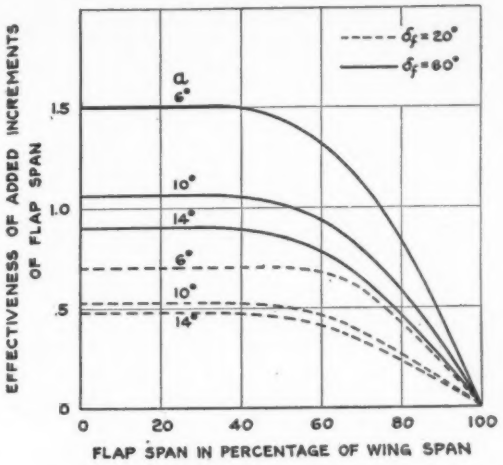
ASSUMED VORTEX SYSTEM

FIG. 5



VARIATION OF LATERAL CENTER-OF-PRESSURE LOCATION WITH FLAP SPAN

FIG. 6



EFFECTIVENESS OF ADDED INCREMENTS OF FLAP SPAN

FIG. 7

increment of lift due to flap deflection the strength of the vortex system can be calculated. The slope of the lift curve, for the airfoil-flap combination, together with the induced angles of attack along the span, which are obtained directly from the vortex strength, provide a means of computing the increment of loading at any point along the span. This increment of load can be defined as

$$\Delta K = a \frac{\Delta C_L S_c}{4 \pi b^2} \left(\frac{1}{r} + \frac{1}{b_f - r} \right)$$

where ΔK is the increment of load, at any point along the span, due to the partial-span flap deflection.

a, the slope of the lift curve for the airfoil-flap combination.

ΔC_L, the increment of lift from the plain airfoil loading due to deflection of the partial-span flap.

S, the wing area.

c, the section chord.

b, the wing span.

b_f, the flap span.

and r, the distance from the flap tip to any spanwise point.

By the application of the above relationship the resultant loading for a combination with any partial-span flap can be determined. It is to be remembered the vortex system assumed increases the induced angles of attack over the flapped portion of the airfoil and hence the increment of load must be subtracted from the basic loading. Outboard of the flap tip the vortex decreases the induced angles of attack and ΔK is added to the outboard basic loading. Sufficient research has been conducted to provide the necessary information for the above solution. As can be seen from Figs. 2 and 3, the span load diagrams, derived by this method, are in fair agreement with the experimental data for short partial-span flaps at small flap deflections. The discrepancy from the experimental results is no doubt due to the failure of the assumptions to hold true when the flap tip vortices come in proximity to the wing-tip vortices.

A more satisfactory approach to the experimental results, although slightly more tedious than the previous method, is obtained by the use of the well-known Lotz method for calculating the aerodynamic characteristics of wings. This method, based upon the solution of a Fourier series, has been presented in a readily usable form by B. S. Shenstone in the May 1934 issue of the Journal of the Royal Aeronautical Society. In applying this method of approach to the experimental results, the increment of loading per unit span due to the flap deflection is computed for all points along the span and added to the plain airfoil span loading. As can be seen from Figs. 2 and 3, the resultant loading curves are in close agreement with the experimental results for all conditions of test.

The variation of the lateral center-of-pressure location in percentage of the semispan from the plane of symmetry is shown in Fig. 6 plotted against flap span

in percentage of the wing span. Curves are given for several angles of attack and for two flap angles, 20° and 60°. For the range of flap spans tested, approximately 30 to 100 percent of the wing span, the location of the lateral center of pressure moves outboard from the plane of symmetry with an increase in flap span for all angles of attack and flap deflections investigated. This movement bears approximately a linear relationship with flap span and is greater for the large flap deflection. For a constant flap angle the rate of travel with flap span decreases as the angle of attack increases, and for large angles of attack becomes quite small.

The curves shown in Fig. 7 represent the effectiveness of extending the flap span of the 20 percent chord flaps as tested on the U. S. A. 45 airfoil and are shown for two flap deflections and several angles of attack. This effectiveness or relative efficiency of added increments of flap span is defined as the rate of increase of C_N with flap span. In order not to limit these curves to a specific profile or span, the effectiveness as plotted is the rate of increase of the airfoil-flap combination normal-force coefficient in terms of C_{N_0} (the normal-force coefficient of the plain airfoil at the same angle of attack) with flap span in percentage of wing span. These curves provide a means of determining the normal-force coefficient of an airfoil-flap combination similar to the one tested. An integration of the area under the curves gives the increase in normal-force coefficient over that of the plain airfoil for any desired flap span. As expected the "effectiveness" is greater, at a constant angle of attack, for the larger flap deflection. For a constant flap angle and angle of attack, the effectiveness of the added increments of flap span remains essentially constant with increasing flap span to a value of flap span of approximately 60 percent of the wing span. From a consideration of these curves it would seem that little is to be gained in normal-force coefficient by extending a split flap of the type tested beyond 70 percent of the wing span.

Conclusions

1. A satisfactory determination, for all conditions of test, of the span load distribution for an airfoil equipped with a partial-span split flap may be made by applying the Lotz method of calculating the aerodynamic characteristics of wings. The increments of load due to the deflection of the flap are computed by the Lotz method and added to the span load distribution for the plain airfoil.

2. By assuming the flap to be replaced by a simple U-vortex, trailing from the flap tip, a method less tedious than the Lotz method may be derived for computing the span load diagrams. This method affords a fair approximation to the experimental results only for short partial-span flaps at small flap deflections.

3. For the range of flap spans tested the location of the lateral center of pressure moved outboard, from the plane of symmetry, with an increase in flap span for all angles of attack and flap angles investigated.

4. There is little to gain in normal-force coefficient by extending the flap span for a split flap of the type tested beyond 70 percent of the wing span.

The Effect of Tubing on the Indications of an Airspeed Meter

Presented at the Aircraft Operations Session, Fourth Annual Meeting, I. Ae. S.

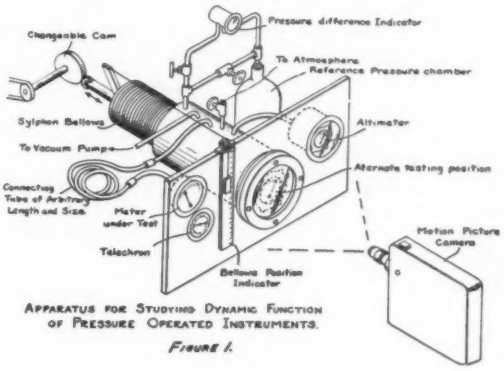
W. R. WEEMS, *Massachusetts Institute of Technology*

AN airspeed meter that reads correctly may be defined as one which indicates at every instant an airspeed corresponding to the pressure difference between the impact and static openings of the Pitot head. From time to time, however, the question arises as to the possible errors introduced in the airspeed indication by the long tubing connecting the instrument and the Pitot.

With the cooperation of W. A. Reichel, of the Pioneer Instrument Company, an investigation was undertaken at M. I. T. to determine the nature and magnitude of these effects. The method followed has been to impose upon the airspeed meter and tubing installation pressure changes typical of those occurring in flight.

Fig. 1 is a schematic diagram of the apparatus used. By means of a properly designed cam, the sylphon bellows is made to move so as to give an arbitrary variation of pressure within the cylindrical chamber. Various lengths and sizes of tubing are used to connect the chamber to either the static or the impact opening of the meter. Time and displacement records are obtained by use of the electric clock and position indicator shown in the diagram. Fig. 2 is a photograph of the apparatus, showing the addition of a small electric light in front of the chamber. This light flashes on at various positions of the cam, thereby aiding in the synchronization of the various records.

In flight maneuvers, the impact pressure may be expected to vary (with time) at a considerably higher rate than the static pressure. A rough calculation makes this apparent, when it is remembered that a change of impact pressure represents an acceleration, while a change of static pressure represents a change of altitude. For example, in the arbitrary dive maneuver used in these tests (to conform roughly to flight data in N.A.C.A. Technical Report 369), about 800 feet altitude was lost in 7 seconds, representing a rate of change of static pressure of about 0.38 cm.H_2O/sec., whereas the rate of change of impact pressures reached ten times this value. We assume, then, that to a first approximation the effect of the tubing can be found by considering the changes of impact pressure alone. When such a change occurs, there will be a flow of air through the impact tubing and also a flow through the static tubing, due to the change in displacement of the pressure capsule. The results shown below were obtained with the impact side of the instrument connected to the pressure chamber, the static side being open to the room. The method may easily be extended to include the effects of tubing on the static side.



APPARATUS FOR STUDYING DYNAMIC FUNCTION OF PRESSURE OPERATED INSTRUMENTS.

FIGURE 1.

In analyzing the effects of the tubing, a reasonable method is to assume that the copper lines are equivalent to capillaries; that is to say that the mass rate of flow follows Poiseuille's Law: $dQ/dt = (\pi/8\nu)\ (R^4/L)\ \Delta P$, where ν is the kinematic viscosity of air, R is the radius of the tube, L is its length, and ΔP is the pressure difference across the ends of the tube. This law is accepted as being valid for Reynold's Numbers less than 1160, where $R.N. = RV/\nu$, V being the average velocity of flow through the tube. This law has been applied for the case of altimeters by Dr. W. G. Brombacher of the Bureau of Standards in N.A.C.A. Technical Note 503. Its validity for the case of airspeed meters is demonstrated in Fig. 3, where a curve for R^4/L of 1.7×10^{-8} obtained with copper ($\frac{1}{8}''$) tubing falls in its proper place between the curves for

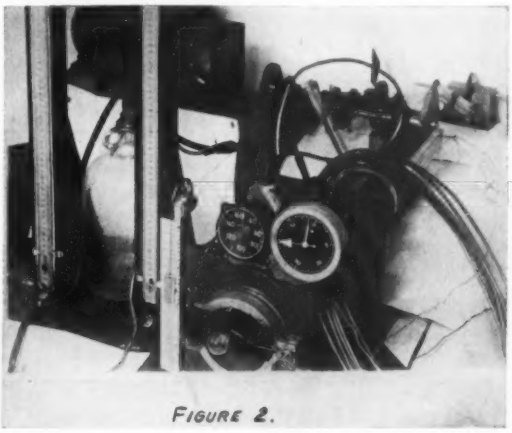
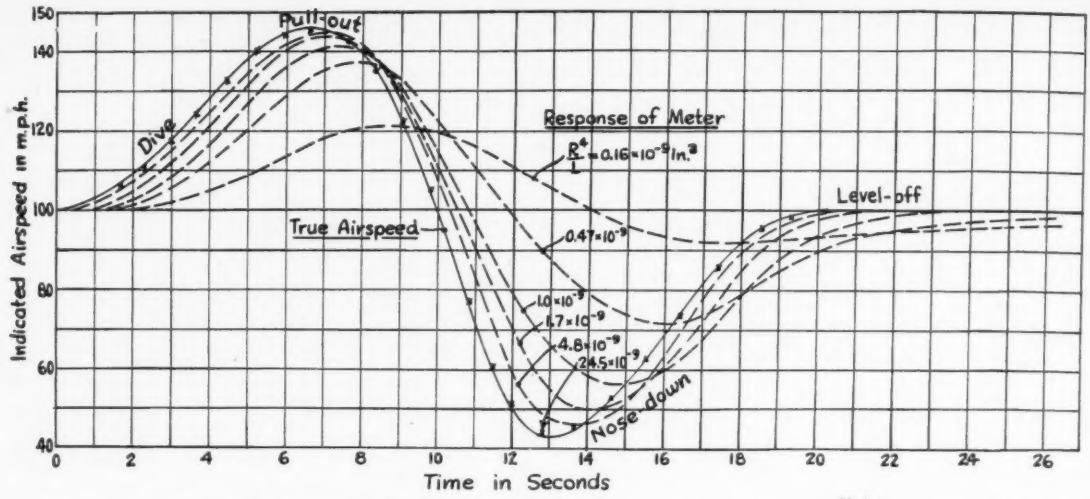


FIGURE 2.



Experimental Response of Airspeed Meter in Arbitrary Dive and Pull-out for Various Values of $\frac{R^4}{L}$ of Connecting Tubing

Notes

1. x x x Experimental points for $\frac{R^4}{L}=24.5\times10^{-9}$
2. $\frac{R^4}{L}=1.7\times10^{-9}$ test made with 40′ of $\frac{1}{8}$″ tubing.
3. $\frac{R^4}{L}=24.5\times10^{-9}$ equivalent to { 2.8′ of $\frac{1}{8}$″ tubing; 60′ of $\frac{3}{16}$″ tubing.

$\frac{R^4}{L}=0.16\times10^{-9}$ equivalent to { 425′ of $\frac{1}{8}$″ tubing; 9030′ of $\frac{3}{16}$″ tubing.

FIGURE 3.

R^4/L of 1.0×10^{-9} and 4.8×10^{-9} obtained with short lengths of glass capillaries. With the validity of the capillary assumption demonstrated by this and other tests (not shown), glass capillaries were substituted for the copper lines, and the other curves of response shown in Fig. 3 were obtained. This procedure makes not only for convenience but also for accuracy, since the volume of air in the connecting lines is thus kept negligibly small compared to that in the pressure chamber.

Referring to Fig. 3, it will be observed that the use of ⅛″ tubing will not introduce an intolerable lag in any reasonable installation. In order to facilitate calculations of R^4/L, the following measured effective values for the three standard sizes are given:

R^4/L of one foot of ⅛″ tubing $= 68 \times 10^{-9}$ in.^{3}
R^4/L of one foot of 3/16″ tubing $= 1485 \times 10^{-9}$ in.^{3}
R^4/L of one foot of ¼″ tubing $= 4800 \times 10^{-9}$ in.^{3}

Note that to obtain the effective R^4/L of a given length of tubing, the above values should be divided by the length in feet. Note also that although R^4/L has the dimensions of a volume, it does not represent any physical volume.

The laboratory technique described makes it possible to determine to what degree a given meter and tubing installation will respond to a given arbitrary variation of airspeed. It is, moreover, desirable to have a theoretical means of predicting this response with reasonable certainty without the necessity of constructing a cam to give the arbitrary pressure variations.

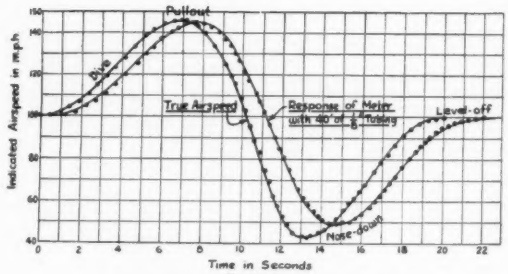


FIGURE 4.
TRUE AIRSPEED AND RESPONSE OF AIRSPEED METER (WITH 40 FT. OF ⅛ IN. TUBING) IN ARBITRARY DIVE AND PULLOUT
Curves show theoretical values.
Dots show experimental values.

To this end, the ordinary theory of one-dimensional systems has been applied. Fig. 4 shows the experimental and calculated responses of a certain arrangement to a slightly modified form of maneuver of Fig. 3. It will be noted that the agreement is remarkably good, certainly within the experimental error. In order to apply the theory to a given case, two things are necessary, (1) a mathematical expression must be fitted to the curve of true airspeed, and (2) one or two observations must be made of the response of the instrument to a sudden change of pressure. Fig. 5 illustrates the kinds of transient responses that may be expected under these conditions. Figs 5(a) and (b) represent the highly oscillatory and overdamped cases of the one-dimensional system.

Figs. 5(c) and (d) are for identical conditions, except that in the latter, tubing of large bore was used. It will be seen that there is very definite evidence of

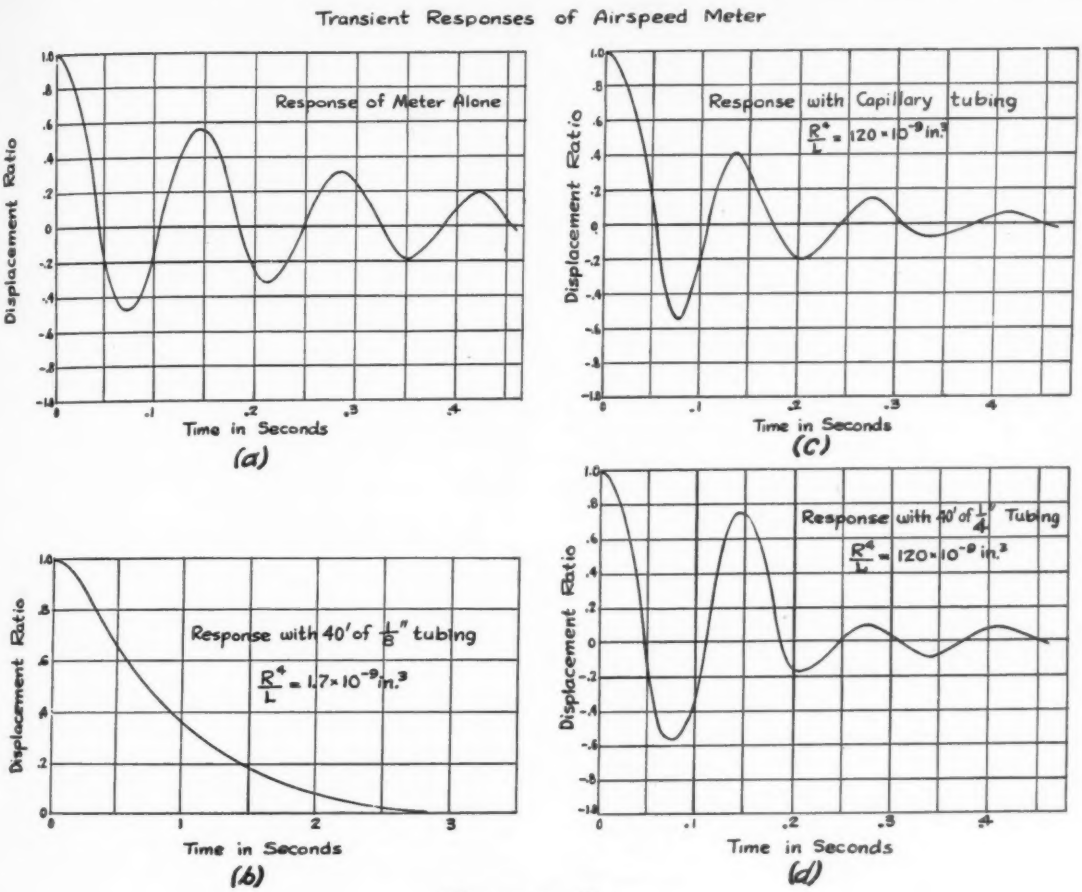


FIGURE 5.

beats. This appears to be due to pressure waves set up in the tubing by the sudden change of pressure at one end. Noting that the natural period of the meter itelf is about 0.15 sec. and considering the tubing as a pipe closed at one end, it is seen that for a length of 40 feet the vibrations of the air column are in resonance with the meter. This effect is not believed to be of great consequence, but leaves the possibility of unsteady readings on an airspeed meter with connecting tubing in the neighborhood of 25 to 50 feet in length. By using smaller (1/8") tubing this phenomenon can be avoided. It should be observed that the airspeed meter used in these tests (which is typical of present-day installations) will follow any reasonable variation of the actuating pressure without exhibiting any detectable lag effects of its own.

In summary, we may list the following conclusions:

1. The connecting tubing of an airspeed meter behaves essentially as a capillary.

2. The theory of the one-dimensional system can be used to predict satisfactorily the response of a given meter and tubing installation to an arbitrary variation of airspeed.

3. For ordinary installations of standard 3/16" tubing, no appreciable error is introduced by the tubing, and 1/8" tubing may be used for most cases, with a saving in weight.

4. The smaller tubing may be further useful in damping out vibrations of the enclosed air column, which can cause unsteadiness of the pointer if 3/16" tubing of length in the range 25 to 50 feet is used.

True Blind Flight

Presented at the Aircraft Operations Session, Fourth Annual Meeting, I. Ae. S.

LUIS DE FLOREZ, *New York City*

THE theory and practice of so-called "blind flying" is now well understood, thanks to the valuable work of Ocker, Crane, Stark and other pioneers in this field. It is now fully realized that the pilot, either consciously or unconsciously, depends on some outside visual reference to maintain flight and that when deprived of such a reference his only recourse is the reading of suitable instruments which provide a substitute. That the most experienced air man cannot fly in the fog without suitable instruments is no longer challenged in aeronautical circles. The knowledge that even birds are unable to fly without sight is convincing proof of the inadequacy of animal senses to permit orientation in space.

A series of experiments conducted by the writer has established that aural "reference axes" may be substituted readily for visual ones in blind flying (instrument flying)—thus freeing the eyes from their present instrument board-bondage during flight through fog and making it possible to use them without interruption for important developments that may be occurring either outside or inside the airplane. *In other words, the ears are capable of supplanting the eyes in blind flying.*

It is the object of this paper to describe experiments with an apparatus designed to produce and use sound as a reference in blind flying. The possibilities of such a system are obvious. Every pilot who has had occasion to fly by instruments knows the tremendous burden this type of flying imposes on the eyes, even after long practice has reduced to a minimum the nervous strain of translating the various dial readings into actual movement of the controls. He knows, too, that there are many things bearing on his safety and peace of mind and calling for visual attention in addition to the concentration which his blind flying instruments require. There are fuel gauges and engine instruments to watch which, at any moment, may flash a warning of vital import. There is the necessity of maintaining a continual watch ahead and below for breaks in the fog, other ships, and the sudden appearance of obstacles. Only the man who has flown blind without a co-pilot to help him knows how often one wishes that he dared take his eyes off the instrument board long enough to jot down a radio weather sequence or study his map and decide what he is going to do next.

Sight plays such an important part in our daily activities that we seldom stop to think of the remarkable role played by the sense of hearing. Through the mechanism of our ears we are able to distinguish instantly differences in the frequency of sound and at the same time detect change in beat or rhythm. Furthermore, our ears detect the direction of sound through what is known as the "binaural" sense with which virtually everyone is endowed. This directional sense is based on the ability of the brain to interpret differences in phase and volume of sound which occur when sound waves strike the ears unevenly. Curiously enough, the binaural sense is effective even though the ears are not equally sensitive, those who are partly deaf in one ear being able to recognize the direction from which a sound comes through experience and mental compensation.

Initial experiments to determine the possibility of employing the aural rather than the visual sense in blind flying dealt with sound-producing apparatus—first, to obtain directional effect by shifting sound in ear-phones; second, to determine sensitivity of the ears to changes in pitch and the tendency of this sense to become dulled by fatigue. The object was utilization of the binaural sense for directional indication, and varying pitch for changes in speed. Since the average commercial ship needs but two controls to keep it in flight (rudder and elevator or ailerons and elevator), the two indications sought were direction and the fore-and-aft attitude of the plane, although it is also entirely possible to indicate the third axis of flight (lateral stability) by aural means. In the actual test flying, which was done with a Fairchild 22 open-cockpit monoplane, it was found unnecessary to complicate the experiments with lateral indication in view of the ship's inherent stability which enables it to be flown by rudder alone, even in rough air, by trimming the stabilizer for level flight and making only occasional fore-and-aft corrections on the stick.

The laboratory apparatus for producing sound consisted of a six-toothed inductor wheel rotating between the poles of two electro magnets in a manner to produce alternating currents in the circuits and set up a hum in each of a pair of earphones, the pitch of the sound increasing and decreasing with the speed of rotation. Provision was made to vary the position of one magnet with respect to the other, with the axis of the wheel as a center, thus altering the phase relation of the two circuits, and simultaneously changing the position of two rheostats to effect a change in sound intensity, thereby making it possible to simulate the difference in phase and intensity detected by the ears when sound comes from one side of the head or the other.

By putting on the earphones and operating the apparatus at a constant speed (thereby producing a constant pitch note) and adjusting the phase-changer and rheostats back and forth with the eyes closed, it was possible to locate the apparent direction of the sound quite accurately (the average error being about 10 degrees). By sitting in a swivel chair and having someone else operate the apparatus, it was possible to follow the apparent source of the sound all around the room. It was also possible to put the sound apparatus off-center and return it to center by tuning the device until the earphone impulses appeared to be equalized, average accuracies of better than 5 degrees being obtained in the latter case.

Location of the exact source of sound is relatively unimportant, provided a definite indication can be given of the general direction from which it comes. The mechanism may be geared up so that a change of a few degrees or even a fraction of a degree in the attitude of the aircraft can be amplified to an apparent change of 15° or 20° or even more in the earphones.

The second phase of the experiments was to determine whether the average ear could remember and return to a given pitch. This was done by varying the speed of the wheel and returning it approximately to the same pitch (as determined through the earphones), then noting the position of the rheostat. It was found that this could be done with reasonable accuracy although, in time, the ear became somewhat fatigued. Changes in pitch, however, are quite noticeable and, though long periods on one pitch may blunt the ear, changes are always appreciable. In later tests a beat note or click was superimposed on a constant pitch sound, the beat varying in speed with the rapidity of rotation. This is less fatiguing and, as will be seen later, is more readily applicable to the use of ordinary radio broadcast.

For flight test, the pitch sound was produced by a small, wind-driven magneto attached to the flying struts and well out of interference with the wing. The gyro mechanism and turn indicator in the plane were relied upon to shift the sound from one ear to the other. To test the apparatus in flight without going to elaborate mechanisms, it was decided to operate merely with two electrical contacts, a turn to the right bringing the sound in the right ear and vice versa. The contacts were adjusted to approximately one quarter of the turn indicator's pointer width.

In the first use of the device as described, the ship was taken to a safe altitude and flown for some time in the normal manner while the writer became accustomed to the alternating sound effects in the earphones. The first apparatus did not have very great volume in the earphones and required placing these directly on the ears, which in itself proved somewhat fatiguing; also the extent of the turn could not be told. As a result, it was necessary occasionally to shake the ship left and right with the rudder to determine how far it had progressed in one turn or another. By shaking the ship the signal would come into each ear alternately when in level flight but when it was banked to a considerable degree additional rudder would have to be applied to one side to get this effect, thus supplying a crude means of determining the attitude of the ship. In spite of this limitation, the writer was able to fly the ship blindfolded for more than 40 minutes.

This phase of the experiments was conducted with the aid of James B. Taylor, Jr., as check pilot. The writer sat in the front cockpit, without instruments, blindfolded and flew with his head down. During the first part of the flight, the ship climbed gradually from about 1500 feet to 2200 feet in a spiral some four miles in diameter. Thereafter the spiral widened out and toward the end of the flight the ship was flying a fairly straight course. The writer, of course, had no sense of direction but merely knew whether the ship was turning or was diving or stalling.

The elevators were used very little. After completing about a half hour of flying, turns were made at the check pilot's command in both directions without difficulty. During the last ten or fifteen minutes of the flight the ship had climbed into the clouds, unknown to the writer, and was actually flying in fog. The writer then was called on to remove his blindfold and continued to fly in the fog without visual instruments. Following this test, the ship was put into a spin with the writer again blindfolded; he recognized this maneuver only as a violent turn which was corrected for and the ship brought back to normal flight after somewhat more of a dive than usual, the only control used being the rudder.

From these tests it appeared very definitely that aural references could be substituted for visual ones in blind flying and further tests were made to ascertain the best methods of obtaining the sound indications required. As mentioned previously, a continuous pitch note is somewhat fatiguing to the ears so that its use as a signal seems inadvisable. Either the note should be changed over some fairly wide range, interrupted, or else something such as broadcast radio employed if the aural senses are to be used for any extended period in controlling the ship.

To this end earphones were connected separately to a radio receiver, each having its own rheostat to vary or modulate the sound. It was found that with sound of varying pitch, merely changing the intensity of sound from one ear to the other is quite sufficient to give directional indications. It was found also that a periodic beat produced by partially breaking of a circuit gives an excellent idea of speed since our hearing is conscious of and very sensitive to rhythm and the slightest changes in timing. Instead of increasing the pitch corresponding to the sound of airplane wires in

a dive or lowering it to indicate climbing or stalling, the rapidity of the beats was changed to increase with dive and decrease with loss of flying speed. This is quite effective and, if the circuit is not cut completely but the volume merely changed considerably on the beat, the disagreeable effect on the ear is minimized.

The second apparatus tested in flight consisted of a two-contact bank-and-turn indicator with a somewhat different type of sound generator, such that with the ship flying straight no sound was received in either ear. As the ship began a turn, a low sound would appear in the ear corresponding to the direction of turn within about ⅛ of a pointer width, this sound increasing on the second contact at approximately a full pointer width deviation. No difficulty was experienced with this apparatus since the ears were resting for the most part, at the same time the extent of turn could be readily appreciated. All subsequent flight test work has been done on the apparatus so connected.

The latest arrangement consists of an air operated servo motor which follows the movement of the turn instrument to vary electrical resistances to completely modulate the sound from one ear to the other without steps. This apparatus is now awaiting flight tests, together with radio receiving equipment which will give directional information as well as stability indications.

The next step obviously lies in combining this new method of blind flying with navigation along a given course by sound, and experiments are now being conducted in this field which show a great deal of promise. It may be said briefly that one line of investigation being followed has to do with a pair of direction-finding radio loops, set some distance from each other on the plane and at a slight angle to one another so that they afford a method of triangulation on a broadcasting station or other transmitter which gives the effect of the binaural sense in man and allows the airplane to "face" the sound which it is using as a navigational focus just as the pilot faces the mechanically produced sound in his plane that warns him when he starts to veer from straightaway flight. On this development the writer hopes to have more to report at a future date.

Model Experiments on Flutter at the Massachusetts Institute of Technology

Presented at the Aerodynamics Session, Fourth Annual Meeting, I. Ae. S.

MANFRED RAUSCHER, *Massachusetts Institute of Technology*

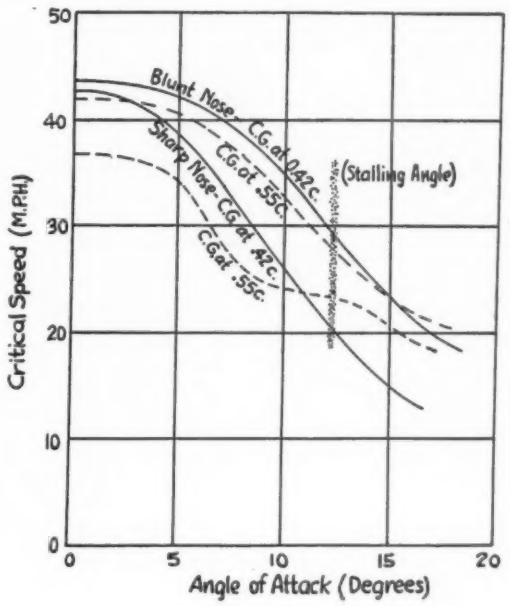
FLUTTER studies were begun at M.I.T. in 1926. v. Baumhauer and Koning's fundamental work[1] on flexural-aileron flutter had just been followed by that of Blenk and Liebers[2] on flexural-torsional flutter, and a combination of the two partial theories into a complete theory of flexural-torsional-aileron flutter was in prospect. Our intention was to aid this development by establishing the validity of Blenk and Liebers' theory in its limited field.

Our experiments showed that the theory was not yet satisfactory, the observed critical speeds being far from the calculated ones. Some of the secondary causes of the theory's failure, such as the disagreement between the assumed and the observed forms of bending and twisting of the wings, could readily be eliminated.[3] But the primary defect of the theory was seen in its reliance on improper aerodynamic inertia and damping factors. A study of these factors thus became the basic problem.

Work was begun in 1930 on an oscillator to give an airfoil a linear harmonic motion at right angles to the air stream and an angular harmonic motion in pitch, with arbitrary phase relations between the two motions. The amplitude and the frequency of the oscillations will be adjustable within wide limits to permit independent variations of the velocities and of the accelerations over a large range. Induction elements in the suspension wires will furnish continuous records of lift, drag, and pitching moment.

Pending the completion of this rather slow investigation, model experiments have been made to determine empirically the effects of various factors on flutter. Models 30 x 5 inches in size, with spruce spars and paper ribs, and covered with thin rubber, were used. Lead weights attached to the spars permitted variations of the wing mass, C.G. location, and moment of inertia. The wings were mounted with some elastic play on a balsa wood fuselage which was normally held fixed, but was made to be carried freely by the wings in certain tests.

Fig. 1 shows the general dependence of the critical flutter speed on the angle of attack. It suggests that a pilot should not try to stop flutter by pulling his machine up. (By supplementary tests made at 10° yaw, skidding was found to have no effect on flutter and thus to be a safe means of reducing the flying speed.)



INFLUENCE OF ANGLE OF ATTACK AND AIRFOIL SHAPE ON FLEXURAL-TORSIONAL FLUTTER (30"×5" MODELS)

FIG. 1

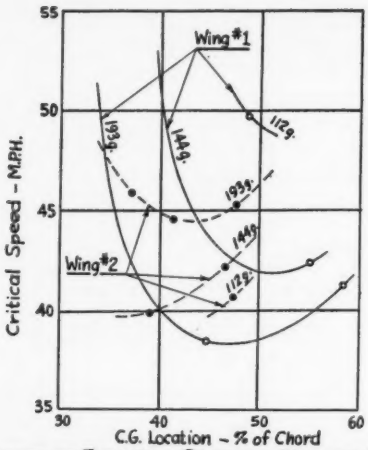
The dropping of the critical speed with increasing angle was always accompanied by a growing predominance of the torsional component of the motion over the flexural one. This partly explains why the effect of C.G. location decreases toward the higher angles of attack. As a rule, the flutter was symmetrical at low angles when the C.G. was forward and the flexural motion predominated; when the flexural motion became subordinated—as at a high angle of attack, or because the C.G. was far in the rear—antisymmetrical flutter would frequently appear at critical speeds apparently in line with those corresponding to symmetrical flutter.

The figure indicates a surprising difference between the flutter characteristics of two wings differing only in their profiles. (The "sharp" nose was one with about twice the curvature of an ordinary nose; the "blunt" nose had a curvature about one-half of normal. Both wings had a maximum thickness of 1/10 chord, located at 1/3 of the chord.)

[1] Reproduced in N.A.C.A. Technical Memorandum No. 223, *On the Stability of Oscillations of an Airplane Wing.*

[2] *Schwingungen Freitragender Flügel.* Z.M.F., 1925.

[3] M. Rauscher, *Schwingungen Freitragender Flügel,* Luftfahrtforschung, 1928.



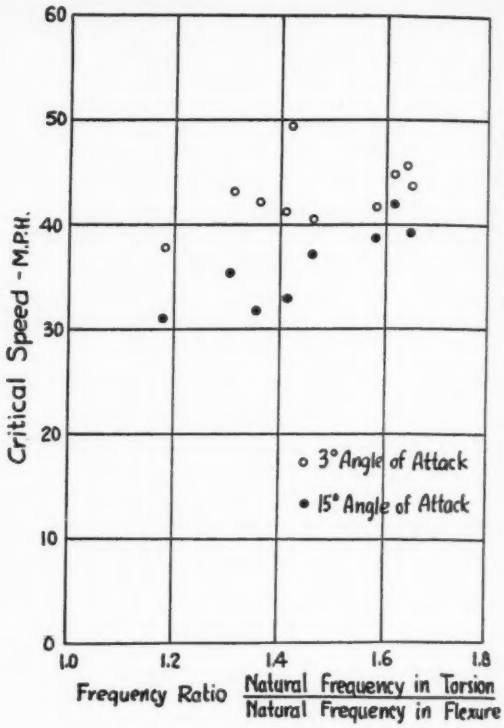
EFFECT OF FLEXURAL STIFFNESS, MASS AND C.G. LOCATION ON FLEXURAL-TORSIONAL FLUTTER

Models 30"x5". Angle of Attack 3°. Wing #2 has the same torsional stiffness as Wing #1, but double its flexural stiffness. Elastic axes of both wings at .26c. Mass of wings given in grams.

FIG. 2

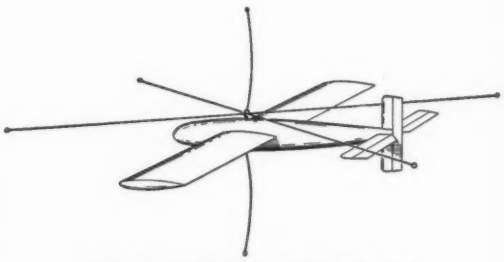
The study[4] to which Fig. 2 refers, was inspired by the rather general feeling that stiffness in any form helps toward the suppression of flutter. The figure shows that not only changes in the flexural stiffness, but also shifting of the C.G. and changes in the mass of the wing, have effects which may be good or bad, depending on other factors. That all the factors cannot simply be lumped together into the ratio between the natural frequencies of the wing in torsion and in flexure is shown by Fig. 3, based on the same data as Fig. 2: the trend toward higher critical speeds at the higher frequency ratios is so vague as to mean little.

Figs. 1, 2 and 3 are based on tests in which the fluttering wing was mounted on a fixed fuselage. To determine the effect of this fixity, tests were made with a suspension, as shown in Fig. 4, the model just lifting its own weight as it reached the critical speed. With fuselage weights between four and six times the weights of the wings, and at angles of attack around 2°, the fuselage mobility was found to have no perceptible effect on the critical speeds. It was also found that antisymmetrical flutter developed just as readily with a free fuselage as with a free one.



EFFECT OF NATURAL FREQUENCY RATIO ON FLEXURAL-TORSIONAL FLUTTER

FIG. 3



MODEL SUSPENSION FOR "FREE FLIGHT" FLUTTER TESTS

FIG. 4

[4] Bailey and Bentley, *The Effect of Flexural Stiffness on Flutter*, B. S. Thesis, M.I.T., 1934.

A Survey of Aerodynamics

Presented at the Survey of Aerodynamics Session, Fourth Annual Meeting, I. Ae. S.

CLARK B. MILLIKAN, *Chairman*

California Institute of Technology

At the survey session on aerodynamics Dr. Millikan first gave a brief resumé of certain problems in aerodynamics which have been actively pursued during the past year, and in connection with which there still remain unsolved problems. His outline of topics was divided into three parts: airfoils and wings, airplanes, and fluid mechanics.

In the first section the development of the new N. A. C. A. "five digit" airfoil family was discussed, and the desirability of further investigations on the basic thickness function was suggested. The recent work on high lift devices was touched upon, the question of attaining high lifts by means of suction being specially emphasized. It was suggested that researches on suction wings have now progressed to a point where it would be highly desirable to have investigations on scale models of practicable full scale designs. The unusual characteristics which have been discovered for wings with very small aspect ratio were briefly discussed, and the desirability of pressure distribution measurements on this type of wing was suggested. The problem of tip stall on highly tapered wings was mentioned with the hope that there might later be a discussion from the floor of this very serious problem. Finally the experimental technique which has recently been developed for the study of non-stationary flows, and especially of instantaneous lift values was briefly discussed.

In the second section, that dealing with airplanes, the problem of extrapolating wind tunnel observations to full scale was mentioned, the maximum lift question being particularly emphasized. Modifications to the existing methods of performance analysis and estimation were briefly touched upon in the light of the recent developments in supercharged engines and controllable pitch propellers. The desirability of extending the existing work on the effect of propulsive systems on airplane performance and stability was pointed out and some of the problems in this field which are now being attacked were discussed. The fields of stability, controls and spinning were omitted in view of the discussion which they had received at the previous section.

In the third section, fluid mechanics, the new experimental and theoretical methods which are under development for the flow of compressible fluids were mentioned with the hope that at the next annual meeting a considerable amount of new material would be available for discussion. The unsolved problems in connection with the laminar boundary layer were characterized as being essentially mathematical in nature, while the questions of the transition to the turbulent boundary layer and the characteristics of the latter itself require extensive experimental work before they may be adequately understood. The experiments which are just starting in various laboratories on the effects of pressure gradient, curvature and roughness were mentioned. Finally the question of turbulence was briefly discussed, the remarkable convergence of interest of the meteorologist and the aerodynamicist being especially emphasized. The recent advances by Taylor in the theoretical treatment of problems involving isotropic turbulence were pointed out, but the necessity for much further research in order to discover the basic or elementary physical laws underlying the phenomena of turbulence was emphasized.

Following this brief outline of problems, H. L. Dryden gave a most interesting talk illustrated with slides, on the various techniques which have recently been developed for the study of turbulence. E. N. Jacobs discussed certain of the problems connected with the N.A.C.A. airfoil families and described some of the recent work at Langley Field on the connection between the effects of turbulence and Reynolds Numbers on the maximum lift of airfoils. Th. Theodorsen presented some considerations on his well-known theoretical investigations of the pressure distribution around arbitrary airfoil shapes. T. P. Wright described a very interesting solution which the Curtiss Company had recently found for the problem on the tip stalling of tapered wings. C.-G. Rossby pointed out the analogy between the problems of the turbulent flow of incompressible fluids in curved paths and of compressible fluids where changes in density due to heating and to change in altitude were important. H. Peters discussed some of the experimental work on turbulence which is now being carried on.

HUGH L. DRYDEN

National Bureau of Standards

Experimental Techniques for Studying Turbulent Air Flow. Within the last few years, there has been intensive development of experimental methods for studying turbulent air flow. The simplest case to study is that of isotropic turbulence, in which the several components of the fluctuations of speed are uncorrelated and have the same root-mean-square values. The turbulence in wind-tunnel air-streams is approximately of this type. As is well known, the presence of this turbulence, usually produced by the honeycomb, affects the aerodynamic forces and moments on bodies placed in the stream. In particular, the drag of a streamline-body may vary by a hundred percent and the maximum lift of an airplane wing by thirty percent with changes in the turbulence.

An early measure of the turbulence was in terms of its effect on the force on a sphere. The Reynold's Number at which the drag coefficient of a sphere is 0.3 has been rather generally adopted as a quantitative measure. It has been found necessary to specify the diameter of the sphere, since the critical Reynold's Number, as it is called, varies somewhat with the diameter. Instead of measuring the force on the sphere it has been found more convenient to measure the difference in pressure between holes at the front and back of the sphere. The "pressure-sphere" was introduced independently by the author and Hoerner in Germany. Through measurements by Platt at Langley Field, it has been found that a pressure of 1.22 times the velocity pressure corresponds approximately to a drag coefficient of 0.3.

The first property of the turbulence itself to be measured was the fluctuation of the speed at a point with time. The hot-wire anemometer is the measuring device which has received most attention. With small wires and with suitable amplifiers and compensation networks to compensate for the lag, a fairly accurate oscillogram of the speed fluctuation at a point may be obtained. To obtain a quantitative value, the alternating current, which corresponds to the speed fluctuation, may be directly measured and interpreted as the root-mean-square speed fluctuation. This root-mean-square value expressed in percent of the mean speed is used as a measure of the turbulence.

Other techniques have been developed. Fage has applied the ultramicroscope to observe the motions of the very small

particles normally present in air or water. By using a rotating objective, the minimum and maximum speeds of the particles may be matched to bring the images to rest. The maximum speed fluctuations may thus be measured. Townend identifies small air masses by heating them by means of electric sparks. By measuring their position a short time later and repeating the measurements many times, the fluctuations may be determined. Lindvall has used a glow discharge between two points as an element sensitive to speed fluctuations.

A second property of turbulence which may be used as a quantitative measure is its effect on diffusion. Meteorologists have studied the diffusion of smoke, dust, or even balloons to measure turbulence in the atmosphere. Schubauer has recently utilized the diffusion of heat from a small electrically-heated wire as a measure of the turbulence in wind tunnels. Good correlation was found with hot-wire measurements, and when correction is made for the length of the hot-wire, the root-mean-square transverse fluctuation obtained from the measurements of thermal diffusion is substantially equal to the longitudinal fluctuation measured by the hot-wire anemometer.

In cooperation with the National Advisory Committee for Aeronautics, the National Bureau of Standards has been studying the relation between the critical Reynold's Number of a sphere and the root-mean-square speed fluctuation. The effect of sphere diameter indicates that the scale of the turbulence is of importance. To vary the scale of the turbulence, wire screens of varying mesh but with constant ratio of wire diameter to mesh were used. The turbulence was varied by working at varying distances from the screens. For any one screen, there was a definite relation between critical Reynold's Number of a sphere of given size and the root-mean-square fluctuation, but a different curve was obtained for each screen and sphere combination.

The mesh of the screen is but a crude indication of the scale of the turbulence or average eddy size. Two hot-wires have been used to measure the correlation between the speed fluctuations for varying distances between the wires. When the wires are close together, the fluctuations are identical and the correlation is unity. When the wires are far apart, the fluctuations are randomly related, and the correlation is zero. The area under a curve of correlation coefficient vs. distance apart can be used as a measure of average eddy size. The eddy size is found to increase with increasing distance from the screen, i.e., as the eddies die out.

The correlation measurements can be used as a basis for correcting the observed root-mean-square fluctuations for the effect of the finite length of the wire.

G. I. Taylor has recently formulated a statistical theory of turbulence (*Proc. Roy. Soc.*, London, Vol. 151, p. 421, 1935) which describes the experimental results on eddy decay very well, when the experimental values of average eddy size are used instead of the mesh size. This theory leads to a prediction (developed but as yet unpublished by Taylor) that the critical Reynold's Number of a sphere should be a function of the product of the ratio of the root-mean-square speed fluctuation to the mean speed by the fifth root of the ratio of sphere diameter to average eddy size. Our experiments confirm this prediction.

It is to be expected that the effect of average eddy size will also be found in experiments on the drag of airship models and on the maximum lift of airplane wings.

THEODORE THEODORSEN
National Advisory Committee for Aeronautics

The writer presents herewith a short summary of the work done at Langley Field along theoretical lines. The problem of pressure distribution on airfoils in two-dimensional flow has been treated in a number of reports and I shall mention only the main points of interest. In Technical Report No. 383, *"On the Theory of Wing Sections with Particular Reference to the Lift Distribution,"* it was pointed out that one of the objections to the existing theory of thin wing sections was that it called for an infinite velocity at the leading edge. At one angle, however, there is an exception. This is the angle at which the flow actually strikes in a direction parallel to the surface at the front. This angle was termed the "ideal angle of attack."

The next work along this line was published in Technical Report No. 411, which deals with the pressure distribution on airfoils of perfectly arbitrary shape. By means of a new flow transformation departing essentially from earlier methods, the writer succeeded in producing an exact method for calculating the pressure distribution. This method is powerful enough to obtain the pressure distribution on any shape no matter how irregular. The method is very simple and convenient for practical use. A short exposition of its use is given in *"Aircraft Engineering"* for September, 1935, entitled *"Theoretical Pressure Distribution,"* by G. F. Wallace.

Another phase of this line of work refers to the forces on oscillating airfoils. Some of this work had been done by Wagner and Glauert. The author extended this to include the general case of an airfoil with flap so as to represent three independent degrees of freedom. An exact solution has been made available for the forces. The solution involves two Bessel functions but is sufficiently simple to be of general value. It is of particular interest to note that the forces are considerably out of phase with the instantaneous motions, and smaller in magnitude. This latter work is treated in Technical Report No. 496.

With regard to the practical use of the above work, I may mention that the conception of an ideal angle of attack has been rather essential in developing low drag cowlings. This latter work is at yet unpublished but it has been found that by using a cowl with the wrong kind of leading edge the drag may be increased by as much as 50 to 100 percent.

Stability and Control Research

Presented at the Stability and Control Research Session, Fourth Annual Meeting, I. Ae. S.

HUGH L. DRYDEN, *Chairman*
National Bureau of Standards

The mathematical theory of the stability of an airplane is now old and well known. The stability is determined in the general case by some 36 quantities, which are functions of angle of attack and of the control settings. The complete determination of these 36 functions and the precise calculation of the stability under all reasonable conditions is simply out of the question. Months, if not years, would be required. Fortunately, many of the stability parameters are unimportant. However, little use has been made of the complete mathematical theory in design.

In recent years we have seen advance in three directions. First, in the preparation of generalized charts for the prediction of stability from design data, such as those for longitudinal stability by Zimmerman of the N.A.C.A. By consideration of

all available data, some parameters are neglected, some approximated, and some computed from theoretical considerations. The periods and damping coefficients are then worked out in terms of design parameters such as wing or span loading, etc.

Second, there has been progress in devising convenient methods of solution of the stability equations. You have heard this morning of an electrical device developed at M.I.T. and of a mathematical device developed at N.Y.U.

The third, and in my opinion, the most outstanding development is the use of the spinning tunnel in which the model solves its own differential equations and determines its own parameters. This device has spread throughout the world and in some countries tests in the spinning tunnel are a routine procedure for all new aircraft.

I believe that future development is likely to be along this last line. The development of equipment for studying longitudinal stability in gliding flight would seem relatively simple. The stability with power-on either in spins or straight flight is more difficult. We may yet learn from the boys who play with model aircraft how to accomplish this feat.

The development of these new devices will not supersede the use of autorotation equipment in ordinary wind tunnels, of the spinning balance for force and moment measurements, of the whirling arm for the study of curved flight problems as mentioned by Dr. Troller, and of course, flight tests as the final test. These devices must continue if fundamental research as distinguished from immediate design data is to progress.

In control research, a most significant recent contribution is the discovery that static tests must be supplemented by dynamic tests in which the inertia of the air flow and the motion of the airplane are simulated. You are all familiar with the N.A.C.A. work along this line of which Fred E. Weick will speak a little later.

There has always been a demand for better control at low speeds and for simplification of the controls. Research along these lines has been active and these matters will be discussed, I hope, by some of the experts.

It is hoped that some one may also describe the present status of servo-controls and automatic pilots as well as future trends in their development and use.

ALEXANDER KLEMIN

New York University

Two-Control Operation. The review of the subject was based on field conversations with experienced pilots, and on study of all available theoretical discussions, including the discussor's own previously published article on this subject.

The opinions of experienced pilots were that the difficulty of teaching three-control operation was much exaggerated, and that the fact that two-control was based on indirect reaction, whereas three-control was based on direct reaction, might actually make two-control simpler.

After reviewing the theoretical literature, and the flight tests of the Fairchild F.22 and the Weick W-IA, the discussor offered the following tentative conclusions:

1. Experienced pilots are satisfied with three-control operation and are doubtful regarding the simplification and desirability of two-control operation.

2. Experienced designers, who are less skilled pilots, find fascinating possibilities in two-control operation.

3. With the right combination of moderate dihedral, large vertical tail area and aileron characteristics, satisfactory turning characteristics may be achieved.

4. For stability, large vertical tail area has to be balanced by large dihedral. In such a case ailerons with favorable yawing moment are preferable to ailerons with adverse yawing moment in entry into or recovery from the turn. Ailerons with zero yawing moment are probably the best compromise, however, because of the requirements in the steady turn conditions.

5. With large, but not excessive dihedral, moderately satisfactory turns with rudder alone may be achieved.

6. Aileron control is more promising because it gives less lateral motion, less uncertainty in initiating the turn, and better coordination between the desired yawing velocity and the angle of attack.

7. Skidding or side slipping is never completely eliminated in turning maneuvers, and stability in circling flight with two-control operation will have to be carefully examined.

8. The maneuverability is severely decreased, whichever type of two-control is adopted. Ability to side slip voluntarily with rudder is diminished.

9. Greater skill in aerodynamic design will be necessary with two-control operation.

10. The ability to surmount minor disturbances and the maintenance of a straight course under favorable conditions has been fairly well established. Behaviour in gusty air in cross country work will have to be carefully investigated, theoretically and experimentally.

11. If aileron two-control operation is employed, then very unfortunately at the stall, ailerons of varying characteristics will be needed under varying types of disturbances, and difficulties will arise in case of a spin.

12. Two-control operation merits further attention, but a great deal of theoretical and experimental work remains to be done before its adoption can be seriously considered.

FRED E. WEICK

National Advisory Committee for Aeronautics

The fundamentals of stability have been known for many years, but they have been used by airplane designers to a very slight extent because of the laborious computations required. In order to overcome this difficulty, C. H. Zimmerman, of the N.A.C.A. staff, has made systematic computations covering a sufficient range to include the longitudinal stability of practically all airplanes in power-off flight, and has put the results in easily usable chart form (N.A.C.A. Technical Report No. 521). Similar computations are now being done for lateral stability, power-off. Power-on stability, however, cannot be handled in this simple manner at the present time and there is need for a large amount of experimental data in this field.

In regard to lateral control, which has been found to be difficult of attainment near the stall, the recent work of the N.A.C.A. indicates that satisfactory lateral control cannot be obtained unless the airplane has a certain amount of damping in roll. In order to accomplish this, it is necessary that at least the outer or tip portions of the wings remain unstalled at all angles of attack that can be maintained in flight.

The rather large series of ailerons and other lateral control devices investigated by the N.A.C.A. were touched upon and the development of the slot-lip aileron was illustrated by blackboard sketches.

Digests of Papers on Aircraft Operations

Presented at the Aircraft Operations Session, Fourth Annual Meeting, I. Ae. S.

LOUIS P. HARRISON

U. S. Weather Bureau

Use of Barometric Pressure for Setting Sensitive Altimeters in Airport and Airway Traffic Control. The increasing complexity of the problems involved in the control of airport and airway traffic has necessitated the adoption of a uniform scheme for the setting of sensitive altimeters throughout the country. This scheme, following the proposals of the Weather Bureau at a Conference on Airport and Airway Traffic Control held on November 12–14, 1935, under the auspices of the Bureau of Air Commerce, Department of Commerce, contemplates the use of the pressure measuring instruments employed in the airway weather service (both mercurial and aneroid barometers) for the purpose of obtaining pressure settings pertinent to the various airports, such that if a sensitive (Kollsman) altimeter in an airplane is set accordingly, the airplane can land at an airport to which the setting pertains just as the altimeter hands indicate the surveyed elevation of the landing field above sea level.

In this paper the details of the above-mentioned proposals are presented.

It is first to be pointed out that, assuming radio communication between an observer at the ground and the pilot in the airplane, the use of sensitive altimeters in blind landing and blind cross-country flying presents four distinct problems: (1) the determination of the barometric pressure at the level of the altimeter when the airplane is just at the point of landing on the ground, (2) the precise calibration of the altimeter in accordance with the Standard Atmosphere relation of pressure to height, (3) the determination (or the knowledge) of the elevation of the terrain above sea level in the general neighborhood of the airplane and with reference thereto, and (4) the determination of the mean temperature of the air column between the airplane and the ground beneath.

In regard to the determination of barometric pressure near the ground, it is shown that the mercurial barometer is generally superior both to the aneroid barometer and to the altimeter owing to its greater precision, stability and relative freedom from the various errors inherent in instruments which depend for their indications on the expansion or contraction with change of air pressure of evacuated diaphragm capsules or similar devices. The mercurial barometer thus forms a more suitable standard than either of the other instruments. The aneroid barometer when used in conjunction with a mercurial barometer is found to be advantageous for the purpose of obtaining the desired results expeditiously during intervals intermediate between the times when the readings of the former instrument are compared with the readings of the latter and corrections to the aneroid are thus obtained.

The pressure measuring equipment involved here is already available at a number of stations in the airway weather reporting service.

It is pointed out that with the maintenance of the customary precision employed in the calibration of sensitive altimeters, the procedure under consideration which involves the use of this equipment may be conveniently applied to the checking of altimeters in the field. This is seen to provide an important advantage over the methods hitherto used.

The fundamental mechanical characteristic of the sensitive altimeter is then outlined, viz., that given an appropriate setting therefor, an altimeter can be made to indicate any preassigned altitude reading when brought to a given air pressure, and thence it is shown how the desired setting may be easily determined with the aid of the Standard Atmosphere tables once the air pressure just above a landing field is known and an altitude is preassigned thereto. It is demonstrated that for the sake of speed in procedure it is best to prepare a table of these settings in advance using as the sole argument the air pressure just above the field at the average level of altimeters in landing airplane, *viz.*, about 8 feet.

The altimeter settings under consideration are explained as representing "pressures reduced to sea level in accordance with the Standard Atmosphere." The difference between these "Standard Atmosphere sea-level pressures" and the "meteorological sea-level pressures" employed in the construction of isobars on weather charts is emphasized. It is shown how the latter are of a specialized meteorological character and involve a temperature argument whereas the former do not. A table is exhibited showing how "meteorological sea-level pressures" are determined in practice, and also a table is shown illustrating the differences which arise between the two kinds of data in question at various air pressures and mean temperatures. An isobaric chart is presented for a given occasion and thereafter a chart is portrayed showing the differences between the two kinds of "sea-level pressure" on this occasion in different parts of the country. Then, lastly, there is presented a vertical section delineating the topographic profile of the airway from Chicago, Ill., to Oakland, Calif., and giving a graphical representation of the respective pressures under consideration on the given occasion.

In conclusion, the difficulties involved in pressure altimetry when flying over terrain of rapidly varying elevation are discussed, and the aids which may be obtained by the use of radio beacons and direction-finding apparatus outlined. The suggestion is finally made that a long step might be made toward a solution of this problem if suitable equipment were established on mountain peaks and other strategic elevated points such that automatic radio signals were emitted periodically at short intervals giving the identification or call letters of the station, the actual altitude of the station, and the altimeter setting therefor.

MELVIN N. GOUGH

National Advisory Committee for Aeronautics

Notes on the Technique of Landing Airplanes Equipped With Wing Flaps. The proper landing of airplanes equipped with flaps, although probably no more difficult than landings without them, requires a different technique. The effects of flaps on the aerodynamic characteristics of a wing are given and, with the aid of figures and diagrams, a detailed comparison of the glide and landing of an airplane with and without flaps was made. The dangers attending improper execution and the importance of such factors as air speed, fuselage altitude, glide-path angle, and control manipulation, upon all of which a pilot bases his judgment, were emphasized.

Of most importance in connection with the use of flaps are: The maintenance of a sufficient margin of speed above the stall; a decisive use of the controls at the proper time; more cautious use of power during the approach glide; and, above all, the willingness to accept the steep nosedown attitude necessary in the glide resulting from the use of flaps.

EDWIN P. HARTMAN
National Advisory Committee for Aeronautics

Considerations of the Take-Off Problem. A few random considerations on the take-off problem are herein presented. There is some evidence to show that a great many engineers consider static propeller thrust an important factor in take-off, at least a factor indicative of the take-off performance and the N. A. C. A. has received numerous letters requesting specific static-thrust data to be used for take-off calculations. Fig. 1 has been prepared for the purpose of showing the true importance of static thrust. The area under the triangular plot of velocity/acceleration is proportional to the take-off distance. It is clear from this figure that the initial thrust during take-off has but a very small effect on take-off distance and precise values of static thrust are not necessary for accurate take-off distance calculations.

The most important process in computing take-off is the accurate determination of the propeller thrust in the latter part of the take-off run. For this purpose the data given in N. A. C. A. Technical Reports Nos. 350 and 481 are perhaps the best available at this time. A common error is to use the data in these reports which were obtained on a propeller with an R. A. F. 6 section to calculate the take-off performance of a propeller with a Clark Y section without using an appropriate correction factor. The curves of Fig. 2 represent the take-off of a pursuit plane when equipped with an R. A. F. 6 section propeller and with a Clark Y section propeller of the same diameter. In this example the Clark Y section propeller requires a 39 percent greater distance to take off than the R. A. F. 6 section propeller.

The next problem in computing take-off performance is to obtain the air and ground resistance during take-off and to do this it is necessary to assume an attitude for the plane during take-off. The question is, what attitude to assume? The general resistance equation may easily be written and if the first partial derivative of the resistance with respect to C_L is equated to zero, the following relation results:

$$C_L = \frac{1}{2}\mu\pi A$$

where μ is the coefficient of ground friction.

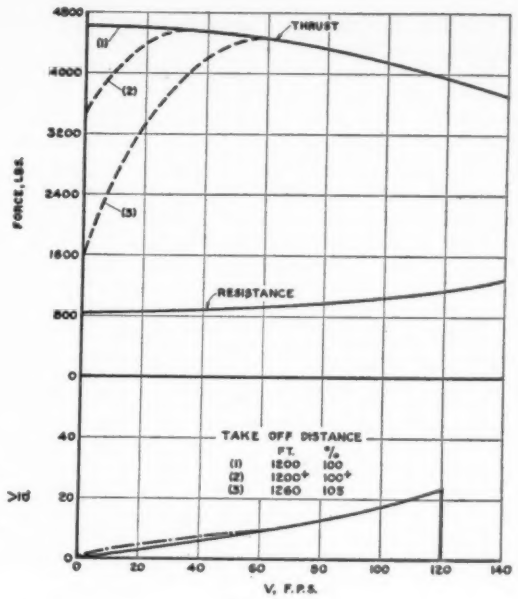
A is the effective aspect ratio including ground effect. This value of C_L will give the minimum air and ground resistance during take-off and for any one plane defines a particular attitude which does not change with velocity. If this value of C_L is substituted in the general resistance equation, the equation for minimum air and ground resistance is obtained:

$$R_{\text{min}} = \mu W + V^2\left(\frac{\rho}{2}f - \frac{\pi}{8}\rho\mu^2 b^2\right)$$

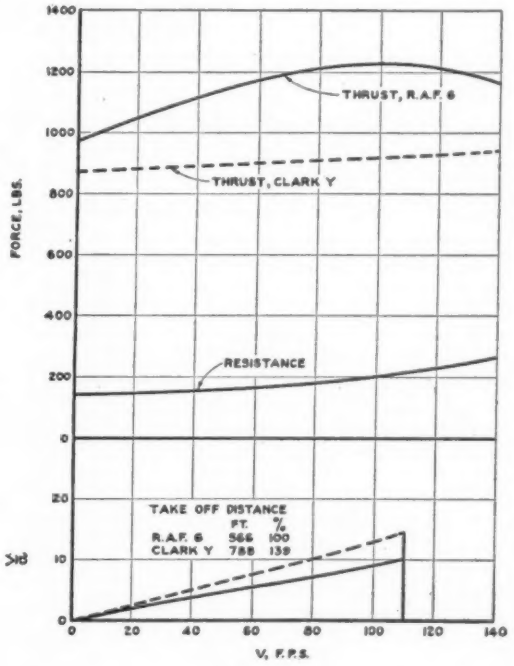
where W is the weight of the plane in pounds

V, velocity in feet per second
b, effective span in feet
f, equivalent parasite area defined by,
parasite drag $= qf$

The particular method of take-off calculation illustrated in Fig. 1 is accurate and fairly short; however, a study of the variables reveals a much shorter method of very nearly equal accuracy. To explain this method it may be said that for all airplanes there is one speed in their take-off run at which the acceleration, if calculated and substituted in the standard equation $V^2 = 2aS$, yields the exact take-off distance. This characteristic speed for all landplanes lies extremely close to the same velocity which is $\sqrt{0.5} \times V_T$ or approximately 0.7 V_T where V_T is the take-off velocity. The short method equation may then be written



[Fig. 1]



[Fig. 2]

$$\text{take-off distance} = S = \frac{V_T^2}{2a} = \frac{V_T^2 W}{64\,T_e}$$

where T_e is the excess thrust calculated at the one characteristic air speed, 0.7 V_T. The effect of inclination of runway may easily be included

$$S = \frac{V_T^2 W}{64\,(T_e \pm W \sin\alpha)}$$

and the effect of wind just as easily by subtracting the wind velocity V_w from V_T

$$S=\frac{(V_T-V_w)^2W}{64\,(T_e\pm W\sin\alpha)}$$

When there is a wind, however, the characteristic velocity at which T_e should be calculated becomes $0.7\ V_T+0.3\ V_w$. Incidentally, the time of take-off for land planes may be determined approximately by the relation

$$t=\frac{1.95S}{V_T}$$

A. R. STICKLEY

U. S. Weather Bureau

Feasibility of Winds Aloft Observations at Sea. A survey has been made of the number of observations of this type obtained over the oceanic areas of the Northern Hemisphere. No correlation exists between the size of the ship used and the corresponding observation lengths. The time available, the experience, skill and persistence of the observers along with cloudiness conditions, seem to be the predominating limiting factors, as was shown by slides. There are certain alterations in procedure and additions of equipment which, if adopted, could do much to improve American methods of taking these observations.

Among the former are: The increase of the stability of the theodolite used by adjusting the counterbalance properly. A theoretical study of this problem has been made by the writer and the results obtained are not satisfactory in some respects. Certain inferences are drawn from these results which it is planned to test shortly.

The use of larger balloons. This will increase the observation lengths in clear weather when the balloon's mean horizontal velocity does not coincide with the velocity of the ship. For the latter we have to consider the use of an "inversion meter" to give a cross-section of the cloud layers when they prevail and the use of a radio-meterograph, such as is being developed by Doctors Curtiss and Astin of the Bureau of Standards, to give wind directions and speed in and above cloud layers as well as below them. There are some difficulties in providing the base line necessary to the use of this method which are to be overcome before the method can be used at sea. Surmounting these difficulties does not seem impossible however, and if and when this is done a complete solution of this and other problems should be provided.

Digests of Papers on Aerodynamics

Presented at the Aerodynamics Session, Fourth Annual Meeting, I. Ae. S.

ALEXANDER KLEMIN AND BENJAMIN F. RUFFNER

New York University

Operator Solutions in Airplane Dynamics. Many problems in airplane dynamics remain unsolved although the basic mathematical theory has long been known. The reason for this lies in the difficulty and labor involved in the application of theory to a specific problem. With modern methods of operator solution the time and labor involved in the solution of problems in airplane dynamics is greatly reduced.

The modern methods of operator solution make it possible to solve for the particular and complementary solutions, to allow for an initial disturbance all in one process with simplification of the mathematical manipulations, greater speed and greater accuracy.

The first application of the new methods consisted of repeating the calculations originally made by E. B. Wilson in 1917 on the effect of a gust on the longitudinal motion of an airplane. The results showed that the new method was more accurate than the older one.

The second problem discussed was that of the motion of a 3000 lb. airplane under the applied recoil of a relatively large gun mounted at 7 ft. behind the center of gravity. The recoil of the gun caused an applied force on the airplane of 1000 lbs. for .3 of a second in a downward direction. The conclusion drawn from this study was that purely from the viewpoint of stability and control, much larger guns than now used could be carried by aircraft without seriously impairing the accuracy of firing.

The third problem was that of the best aileron characteristics for a stable airplane, gliding at or near the stall, and undergoing a disturbance such as that due to a side gust with the rudder not in operation. The conclusions drawn from this study were summarized as follows:

(1) Recovery in roll after an initial disturbance due to a lateral gust, is not only a function of rolling moments of ailerons, but is greatly dependent on the magnitude and direction of aileron yawing moments. It was shown that, in the particular case chosen with constant aileron rolling moment, high favorable yawing moments caused quick recovery in roll but introduced large yawing disturbances; zero yawing moments produced quick recovery in roll and also quick recovery in yaw; and adverse yawing moments produced such high yawing velocities that the machine would roll in a direction opposite to applied ailerons.

(2) Since aileron characteristics usually show considerable variation with angle of attack and aileron displacement, and since the recovery of an airplane after being subjected to a lateral gust is likely to be critically dependent on the aileron yawing moment, a rudder control to compensate for variations in aileron yawning moments appears desirable.

H. PETERS AND J. BICKNELL

Massachusetts Institute of Technology

Study of Mixing Between a Jet of Fluid of Various Densities and Still Fluid. The purpose of the investigation is a two-fold one: first, to determine the ratio between the transfer of momentum and the transfer of matter (salt); second, to determine the effect of stability on the two transfer coefficients. In its present shape, the apparatus is incapable of producing significant stability factors. The first phase of the investigation is therefore concerned exclusively with the ratio between momentum and salinity transfer.

The apparatus consists of a rectangular nozzle 20.3 cm. by 0.3 cm. submerged in a trough of fresh water. Salt water flowing out of the nozzle mixes with the fresh water in the

trough. Density and velocity profiles are taken at four stations downstream, 10, 20, 30 and 40 cm. from the nozzle.

A set of profiles for fresh water flowing through the nozzle agrees with W. Tollmien's theory for a two-dimensional plane jet. A set of profiles for salt water shows salt transfer greater than momentum transfer, in agreement with G. I. Taylor's work on heat and momentum transfer. By plotting the salinity profiles from the different sections non-dimensionally, they can be made to fit a single curve.

A final analysis of the results must be deferred until further observations have been accumulated.

TH. TROLLER
Daniel Guggenheim Airship Institute

The Whirling Arm in Aeronautical Research. The whirling arm, the earliest apparatus for aeronautical model testing, was later almost entirely replaced by the wind tunnel. Some successful attempts in recent times to make use of the whirling arm for such tests as cannot well be handled in the wind tunnel, have been made by Wieselsberger in Goettingen, the National Physics Laboratory, and the Daniel Guggenheim Airship Institute. Successful methods for measuring forces and pressures have been developed and the effect of the swirl has been reduced.

Numerous problems are awaiting treatment by means of the whirling arm. The longitudinal stability is highly dependent on the downwash striking the tail surfaces, which can be properly represented only on the whirling arm, as measurements by Halliday, Bryant, and Burge show (R & M 1556). The lateral stability, particularly at the stall, is affected by the centrifugal forces acting on the boundary layer in curved flight. This also is seen from tests by Halliday (R & M 1642) and is further illustrated by flow pictures taken at the Daniel Guggenheim Airship Institute. An example of the pressure distribution on an airship hull in curved flight is shown, indicating at the same time the forces that may be expected on an airplane fuselage.

Committees for 1936

The following Committees were appointed at the last meeting of the Council:

EXECUTIVE: Glenn L. Martin, Sherman M. Fairchild, Charles L. Lawrance, Edwin E. Aldrin.

FINANCE: Sherman M. Fairchild, Charles L. Lawrance, Grover Loening.

NOMINATING: G. W. Lewis (Chrmn.), Alexander Klemin, Glenn L. Martin, Holden C. Richardson, R. H. Upson.

MEETINGS: G. W. Lewis (Chrmn.), Raymond Haskell, J. C. Hunsaker, Clark B. Millikan, Arthur Nutt, James B. Taylor, D. W. Tomlinson.

ANNUAL DINNER: Luis de Florez (Chrmn.), Geo. B. Post, James B. Taylor.

SYLVANUS ALBERT REED AWARD TRUSTEES: J. C. Hunsaker, Charles L. Lawrance, Lester D. Gardner.

ADMISSIONS: V. E. Clark (Chrmn.), C. H. Biddlecombe, Jerome Lederer, John A. Sanborn, Daniel Sayre.

STUDENT AFFAIRS: Clark B. Millikan (Chrmn.), John D. Akerman, Peter Altman, Wm. G. Brown, Geo. W. Haskins, Bradley Jones, Richard H. Smith, E. A. Stalker.

EDITORIAL AND PROFESSIONAL ACTIVITIES: J. C. Hunsaker (Chrmn.).

(1) Aerodynamics—Clark B. Millikan (Sub-Com. Chrmn.), Walter S. Diehl, Hugh L. Dryden, H. C. Pratt, Richard H. Smith, Harry A. Sutton, Fred E. Weick.

(2) Aeronautical Design, Materials, and Structures—C. H. Chatfield (Sub-Com. Chrmn.), Karl Arnstein, J. H. Kindelberger, Lessiter C. Milburn, Wm. H. Miller, I. Machlin Laddon, T. P. Wright, Th. von Karman.

(3) Education—Harry F. Guggenheim, (Sub-Com. Chrmn.), John D. Akerman, Peter Altman, Th. von Karman, Alexander Klemin, Montgomery Knight, J. C. Hunsaker, Elliott G. Reid, E. A. Stalker, Th. Troller, Baldwin M. Woods.

(4) Instruments—W. G. Brombacher (Sub-Com. Chrmn.), P. R. Bassett, C. H. Colvin, A. F. Hegenberger, W. B. Klemperer, Paul Kollsman.

(5) Metallurgy—A. V. de Forest (Sub-Com. Chrmn.), Paul D. Ffield, C. F. Nagel, Jr.

(6) Meteorology—W. R. Gregg (Sub-Com. Chrmn.), Charles F. Brooks, Irving P. Krick, C.-G. Rossby.

(7) Physics and Radio—Hugh L. Dryden (Sub-Com. Chrmn.), Wm. R. Blair, L. M. Hull, David S. Little, Haraden Pratt, F. M. Ryan, A. F. Zahm.

(8) Power Plants and Fuels—Arthur Nutt (Sub-Com. Chrmn.), Edwin E. Aldrin, N. H. Gilman, C. W. Howard, H. J. E. Reid, A. V. Willgoos.

MEMBERSHIP: Southern California—A. L. Klein; San Francisco—Baldwin M. Woods; Detroit—R. H. Upson; Philadelphia—E. Burke Wilford; Boston—C. Fayette Taylor; Hartford—Frank W. Caldwell; Washington—Richard C. Gazley; Chicago—R. S. Damon; Seattle—C. L. Egtvedt.

I. AE. S. REPRESENTATIVES TO OTHER ORGANIZATIONS: S. A. E.—J. C. Hunsaker; A. S. M. E.—Edwin E. Aldrin; Institute of Radio Engineers—L. M. Hull; Petroleum Institute—Raymond Haskell; New York Museum of Science and Industry—Lester D. Gardner; National Safety Council—Jerome Lederer; Aeronautical Chamber of Commerce of America—C. J. Brukner; Manufacturers Aircraft Association—Eugene E. Wilson; National Aeronautic Association—J. H. Doolittle; American Institute of Mining and Metallurgical Engineers—A. V. de Forest; Guggenheim Medal Board of Award—Glenn L. Martin, Sherman M. Fairchild, T. P. Wright; American Association for the Advancement of Science—J. C. Hunsaker.

Structural Problems

Presented at the Structural Problems Session, Fourth Annual Meeting, I. Ae. S.

JOSEPH S. NEWELL
Massachusetts Institute of Technology

For the purpose of provoking a discussion I will say that the field of aeronautical structures covers three major phases, the determination of the loads on the structure, the determination of the stresses in the members thereof, and the investigation and comparison of materials suitable for carrying these loads and stresses. The first phase involves the interpretation of aerodynamic data and its application to requirements for structural airworthiness. At the present time, it is concerned with the loads created by vertical gusts and with the loads due to structural vibrations, such as wing flutter or buffetting, caused by irregularities in airflow or sychronization with engine or propeller frequencies. It will, perhaps within the next year, be concerned with a revision of the requirements concerning load distribution on wings. It will also, doubtless, be concerned with the evaluation of loads arising from flight at high altitudes.

The second phase will also be involved in the problems of high altitude flights and must develop methods for determining stresses on windows and doors of super-charged cabins, in members subjected to contractions due to low temperatures, and for evaluating the effects of combined stresses arising from the extra loadings involved in maintaining internal pressures in fuselages. Another problem of importance to the stress analyst is the determination of the effect of "shear-lag" on built-up sections of wings and fuselages. Due to the differences in stiffness between the material adjacent to a stiffener and that between stiffeners, there are variations in stress distribution which result in some members carrying less stress than would be expected from normal design theories. It is important that means be established for evaluating this effect. Similarly, a method is needed for determining the effect of cut-outs and openings on stress-distributions. These problems are affiliated in that each involves a variation in stiffness of section with a consequent redistribution of stress, but the methods of attack required for their solution will doubtless differ.

In the fields of new materials or modifications of old ones, there seem to be no outstanding developments or problems. If plastics can be adapted to airplane structures, and it appears that they may be, investigations will be necessary to determine their adaptability, their cost in production and their dependability and permanence. The aluminum alloys and stainless steels still furnish the most practical materials for present day aircraft and the problems involved in their use would appear to be refinements of detail rather than development of new procedures.

The above, I believe, constitute the major problems before the structural man and it is my hope that light may be shed upon some or all of them in the discussions which follow, this summary having been presented solely for the purpose of providing a basis for discussion.

Aeronautical Meteorology

Presented at the Aeronautical Meteorology Session, Fourth Annual Meeting, I. Ae. S.

W. R. GREGG
U. S. Weather Bureau

In opening the symposium on aeronautical meteorology the chairman, W. R. Gregg, Chief of the United States Weather Bureau, commented briefly on two recent developments in meteorological service which he regarded as being of special significance to aeronautics. The first is the action taken by the International Meteorological Organization (I.M.O.) at its meeting in Warsaw in September, 1935, when it organized a new Commission on Aeronautical Meteorology. The second is the rapid progress that is being made in several different countries in the design of radio apparatus for the measurement and reporting of upper air conditions.

In connection with the recent action of the I.M.O., Mr. Gregg recalled that there has been in existence for some thirty or forty years a very active Commission on the Exploration of the Upper Air. Notable work has been done by this commission but chiefly along technical lines. For sometime it has been recognized that there is need of applying in a practical way the knowledge concerning upper air conditions to the actual problems of flying. Accordingly, some ten years ago a commission was appointed for this purpose, but for various reasons it has been relatively inactive. In the meantime other organizations independent of the I.M.O. had arisen, notably the International Commission for Aerial Navigation, and certain regional aeronautical conferences, mostly in Europe. All of these had subcommissions dealing with meteorology. There was need for a coordination of all of these various efforts, and accordingly, as the result of careful study by a special committee appointed for that purpose, the I.M.O. set up a new "Commission on Aeronautical Meteorology" with membership to include representatives of the various bodies above enumerated, these to be designated by the various countries interested. In addition the membership includes certain representatives of the I.M.O. itself, and all action taken by the new Commission must be approved by the president of the parent body.

Mr. Gregg outlined briefly the progress that has been made in the past two or three years in the development of the radiometeorograph in the United States and also in several of the European countries. It is evident that this means of upper air exploration will be brought to a point where it can be used within the near future as a substitute for all other methods heretofore employed. Its general adoption and use will, he believes, mark the beginning of a new epoch in meteorological service, because observations will be possible under all types of weather conditions, to much greater heights than at present attainable and the data will be immediately available, since they will be communicated by radio while the balloon is ascending. These data from a widespread network of stations will not only be of great value in indicating current conditions of interest to fliers, but will also be of tremendous aid in the Bureau's program of developing its forecast service in line with sound physical principles.

Book Reviews

This Flying Game, by BRIGADIER GENERAL H. H. ARNOLD AND MAJOR IRA EAKER; Funk and Wagnalls Company, New York and London, 1936; 275 pages, $3.00.

If newcomers in the field of aviation were to select two guides to show them around they could not find more experienced and able mentors than Brig. General Arnold and Major Eaker.

Every year, there are probably as many as a hundred thousand young people who join one or more organizations which are promoting the cause of aviation. This general movement to arouse the public to the importance of aircraft as an arm of national defence is world wide. What is equally important is to inform each citizen of his duty in case of air raids. In Europe where the need is more immediate, some such leagues have seven or eight million members. In Russia also, the Air League has many millions of members.

"This Flying Game" literally takes the beginner by the hand and leads him through the early history of aeronautics from legendary times, and acquaints him with those who have dared to make great flights. The reader is told in simple language why an airplane flies and then is taken to a training field and given an insight into the requirements and training of a military pilot. Army aviation and Naval aviation and airships share several chapters on their special problems. The aircraft industry with its many trades and professions is introduced and in conclusion the authors project their imaginations into the future and give some of the possibilities which may be seen by the next generation.

In a book which covers such a broad field and treats of many subjects which are controversial the authors have been particularly free from errors of fact. They do, however, neglect to give due importance to the work of the aeronautical schools, the research laboratories, the engineers and the scientists. They start with the airplane ready to fly and carry it from that point forward. When a pilot buys a plane and makes a flight involving personal danger, great endurance and skill, the public gives him all the credit for the achievement. The many factors which were combined to make the flight possible, the several years of work by laboratories, engineers, and unknown test pilots, are assumed to be as purchasable as any other commodity. "This Flying Game" is not different from other popular aeronautical books in minimizing the work of the constructor.

The book is well illustrated and as a contribution by leaders in their field is a timely stimulus to the great awakening to the importance of aircraft that seems to have spread rapidly to all parts of the world.

The Air Annual of the British Empire, 1935-36; Volume VII, edited by SQUADRON-LEADER C. G. BURGE; Sir Isaac Pitman and Sons, Ltd., London; The Pitman Publishing Corporation, New York, 1936; 772 pages, $6.00.

The British are fortunate in having excellent reference publications on aeronautics. "All the World's Aircraft" is unique and serves the whole world. The "Air Annual of the British Empire" is not only a masterly publication of British aeronautical progress from year to year but Squadron-Leader Burge in the seventh volume has taken the occasion of the Silver Jubilee of the late King to cover the history of the aircraft development in Great Britain for the past twenty-five years.

The authoritative value of the Annual is enhanced by the distinguished positions held by the authors of the many signed articles. The heads of the Air Ministry, the Aircraft Industry, the Royal Aeronautical Society and other aeronautical specialists all provide a record of twenty-five years development which makes the book more than merely a record for the year 1935. Lt. Col. J. T. C. Moore-Brabazon, President of the Royal Aeronautical Society, gives a short sketch of the past quarter of a century's activities of the oldest aeronautical society in the world, this period covering only about a third of the life of this famous organization. Merely to read the names of some of the more prominent aeronautical specialists who have been members or lectured before the Society is to call a roll of the most distinguished figures in the history of aeronautics.

Perhaps the outstanding article of general interest is the chapter by J. E. Hodgson on "The Part of Great Britain in the Development of the Aeroplane." It is a condensed version of his classic "History of Aeronautics in Great Britain." The great importance that aircraft have in national development has caused each country to search for records of achievements of its pioneers in aeronautics and display their work to the best possible advantage. France, Germany and Italy as well as England have all made these investigations and published many volumes dealing with aeronautical history relating to work before the Wright Brothers first flight.

It is interesting to read a quotation from an address made by Wilbur Wright at a dinner given in his honor by the Royal Aero Club in May, 1909, in the course of which he said—

"About 100 years ago, an Englishman, Sir George Cayley, carried the science of flight to a point which it had never reached before. . . . This period of high tide was followed by an ebb. But about 50 years ago another period of high tide arrived at a time when Henson, Wenham, and Stringfellow raised the hopes of the world, and carried the art to a very fine point. After a period of depression, a third period of high tide came when Maxim and Phillips and their friends again placed England in the lead in regard to flying, and perhaps it was the irony of flight that brought further success in a period when flying in England was at an ebb tide."

Those who have considered the work of the Wright Brothers *ab initio* and their knowledge of the previous art slight will see, as all informed persons have always known, that their achievement was based not only on skill and inventive genius but on research and a rechecking of the work of previous investigators.

It is natural that some of the claims made for British Aircraft are tinted with that complete sense of superiority which our English friends display when they are seeking foreign markets but which is so conspicious by its absence in private conversation.

The descriptions of the products of the British Aircraft Industry, embracing aircraft, engines, equipment and services covering some six hundred pages is a most comprehensive presentation, pictorially and statistically.

To give the Annual a broader usefulness, sections in French, Spanish and German describe the products of the British aircraft industry.

With a complete statistical section, the Annual is as indispensable to those who wish to have a reference book on British Aviation as our own Aircraft Year Book.

Institute Notes

New Journal Policy

The Council at its last meeting decided that the Journal of the Aeronautical Sciences would in the future carry no advertisements. Of the many reasons for this change in policy the principal one was that the Council felt that the Institute should not draw its support from the advertising appropriations of companies in the aircraft industry and thereby compete with other aeronautical publications. It also permits the Journal to print about twenty-five per cent more technical matter.

The Council has expressed its appreciation to all those companies which have through contributions in the form of advertising made the publication of the Journal possible. A new class of Corporate Membership has been created. Companies engaged in aircraft development may become Corporate Members and thus support the work of the Institute.

Proceedings of the Meeting of the Pacific Coast Section of the I.Ae.S. Held on February 7, 1936

A highly successful meeting of the Pacific Coast Section of the I.Ae.S. was held in Los Angeles on the evening of February 7. Dr. Clark Millikan presided over a short business meeting following the dinner. At this meeting the Executive Committee of the past year was re-elected and two new members were added, namely Lee Atwood of the North American Aviation Corporation, and I. Laddon of the Consolidated Aircraft Corporation. After the business meeting a technical session was held dealing with the theme "Technical Aspects of the Small Airplane Problem." T. P. Wright presented and discussed a paper which had been prepared by A. E. Lombard, entitled "Technological Developments of the Curtiss-Wright Coupe." The paper was illustrated by a number of very interesting slides, and elicited a considerable amount of discussion. Lloyd Stearman spoke on the development of the Hammond plane which was built in connection with the Bureau of Air Commerce small airplane program. Waldo Waterman presented a very interesting film and much historical information in connection with the construction of his "Arrowplane" for the same program. E. P. Warner gave an extremely interesting analysis of the economic and other problems involved in the production of a small airplane which could sell in sufficient quantities to make the use of modern production methods possible. These talks were followed by a very general and active discussion.

Student Branches

Carnegie Institute of Technology. A meeting of this branch was held on February 20th. The principal speaker at this meeting was Foster B. Stulen, of the Propeller Division of the Pittsburgh Screw and Bolt Company. Mr. Stulen, a graduate of the Carnegie Institute, gave a very interesting talk on the history and manufacturing problems of the hollow steel propeller.

On Thursday, March 5th, members of this branch were guests of the Pittsburgh Screw and Bolt Company and were conducted through that division of their plant concerned with the manufacture of the hollow steel propeller.

University of Minnesota. A joint meeting of this branch and the flying club of the University was held on December 6th. Melvin J. Maas, Lieutenant Colonel in the Marine Reserve Flying Corps and a Minnesota Representative to Congress, addressed the group and told of his experiences as a passenger on one of the experimental Pacific flights conducted by Pan-American Airways. A sound film of Pan-American Airways activities in South America was also shown.

A meeting was held January 30th at which Clarence Chamberlin spoke on the modern methods of radio navigation and the types and efficiency of de-icers. The talk on de-icers included the new "sling" type of propeller de-icer.

Necrology

James Henry Scarr, a Member of the Institute, died at his home at Hasbrouck Heights, New Jersey, on February 14th. Mr. Scarr had been the principal Meteorologist for the New York district of the U. S. Weather Bureau since 1926. He was born near South Boston, Ionia Co., Michigan, on January 10, 1867. He attended the State Normal School at Emporia, Kansas, and later studied law. After a short time spent in teaching he was admitted to the bar in 1892. In 1898 he joined the U. S. Weather Bureau and served in increasingly important positions at St. Louis, Mo., Helena, Montana, Sacramento, California and Tampa, Florida. He came to New York in 1909 and for twenty-seven years was in the local office. He was a Fellow of the Meteorological Society.

Owen A. Shannon, Industrial Member of the Institute, died on February 17, 1936. He was born October 23, 1894, in New York City. He was associated with the Manufacturers Aircraft Association and was Assistant Secretary of the Aeronautical Chamber of Commerce from 1923 to 1929. From then until the time of his death he was associated with the Curtiss-Wright Export Corporation.

Personnel Opportunities

The Personnel Bureau serves organizations seeking to employ aeronautical specialists as well as individual members. The Bureau has been the means of arranging several very successful connections for members.

Any member or organization may have their requirements listed without charge.

Available

Engineer and Draftsman desires connection with responsible aircraft manufacturer. Seven years commercial and military experience as design draftsman and stress analyst on all-metal aircraft. Thoroughly familiar with multi-cellular and stressed skin type construction. Write Box 44, Institute of the Aeronautical Sciences.

Engineer wishes to make new connection. Four years of stress analysis, layout and detail design. Has thorough knowledge of Army and new Department of Commerce requirements. M. I. T. graduate. Write Box 45, Institute of the Aeronautical Sciences.

AERONAUTICAL REVIEWS

These brief reviews of recent articles on aviation subjects are published by the Army Air Corps for the information of its officers, and are printed here by permission of the Chief of the Air Corps. The articles listed may not be obtained from the Army Aeronautical Museum Library as these magazines are available to Wright Field personnel only.

Aerodynamics

Further Experiments on Statistical Measurements of Turbulence. H. C. H. Townend. Results of an investigation to determine the possibility of errors in reading cinematograph records of the movements of small masses of heated air in order to obtain velocities. Abstract of (British) Aeronautical Research Committee Reports and Memoranda No. 1655. Aircraft Engineering, February 1936, page 56.

Italy's New Aviation Center. General description of the new aeronautical research institute recently opened by the Italian Government, which will be devoted to studies for the improvement of both civil and military aviation. Aero Digest, February 1936, page 44.

New Wings for a New Germany. E. T. Allen. The last of a series, which discusses the functions of research in the building of new airplanes for Germany. The D. V. L. is compared with the N. A. C. A. and aeronautical research undertaken at Göttingen, Hannover, Aachen, and Stuttgart is reviewed. The large D. V. L. tunnel and that used for the study of freely spinning airplanes are described in detail. Aviation, February 1936, page 23.

Calculation of the Aerodynamic Characteristics of Biplane Cellules. M. A. Toussaint. Calculation of the characteristics of a biplane cellule of finite span from the experimental results obtained with a homologous cellule with an infinite span. The examples given were selected to indicate the important corrections to be made with infinite and finite aspect ratios. La Technique Aeronautique, No. 138, 1935, page 277.

Comparative Measurements of Turbulence by Three Methods. Comparison of results obtained at the National Physical Laboratory with the hot-wire, ultramicroscope, and spark methods for measuring turbulence. Abstract of (British) Aeronautical Research Committee, Reports and Memoranda No. 1651. Aircraft Engineering, January 1936, page 26.

Contribution to the Experimental Study of the Stability of Certain Biplane Cellules at Large Angles of Incidence. M. Nenadovitch and M. Dennis. Results of tests. Very brief abstract from Comptes Rendus des Seances de l'Academy des Sciences, July 22, 1935, page 260. La Technique Aeronautique, No. 138, 1935, page 296.

Experiments on Servo-Rudder Flutter. W. S. Duncan, D. L. Ellis and A. G. Gadd. Results of an investigation of this type of flutter on a model provided with a flexible fuselage. Abstract of (British) Aeronautical Research Committee, Reports and Memoranda No. 1652. Aircraft Engineering, January 1936, page 26.

The Fundamentals of Boundary Layer Theory with Some Applications to Aircraft. H. Leaderman. Paper presented before the student's section of the Society. The physical structure of the boundary layer is described as well as the methods by which the problems have been attacked mathematically to get useful results and to check the theories. The theory of the boundary layer is applied to the calculation of the drag of an airship or of an airplane fuselage under full-scale conditions, as well as to an explanation of the behavior and performance of different types of airfoils. Royal Aeronautical Society Journal, January 1936, page 65.

Measuring Apparatus of the Chalais-Meudon Large Wind Tunnel. A. Lapresle. The concluding installment describing the balance for direct measurement of pitching moments, equipment for exploring the aerodynamic field, multiple manometers for registering local pressures, propeller testing apparatus (with details of the arrangement for measuring propeller thrust) and the electric motors for measuring power and r.p.m. La Technique Aeronautique, No. 138, 1935, page 260.

Pressure Distribution on Wings with Ailerons. W. L. Cowley and G. A. McMillan. Results of research on the pressure distribution over the wings of a large six-engined flying boat which was undertaken to determine the possible loss of aileron effectiveness due to the twisting of the wings under the aileron loads. Abstract of (British) Aeronautical Research Committee Reports and Memoranda No. 1625. Aircraft Engineering, January 1936, page 26.

Stalling of Tapered Wings. R. H. Smith. Discussion of the three independent phenomena involved in the flow mechanics of stalling wings, especially of strongly tapered ones. As the computations leading to the evaluation of the induced velocities along a given wing with taper, warping and a change of section are complicated, the author carries through the computation for the special case of no geometric warping or change of section. He discusses boundary layer, the stability characteristics of flow separation and tunnel wall effects. Journal of the Aeronautical Sciences, January 1936, page 97.

Stalling of Tapered Wings. W. R. Andrews. A reply to Dr. Lachmann's recent article. The author concludes that the pessimistic picture drawn by Dr. Lachmann applies only to the case of a tapered wing having a constant thickness ratio along the span, or to a wing having a reflexed trailing edge where K_{m_0} is almost zero. Flight, Aircraft Engineer Supplement, January 23, 1936, page 1.

A Theoretical Calculation of the Laminar Boundary Layer Around an Elliptic Cylinder and Its Comparison with Experiment. C. B. Millikan. Outline of the von Karman-Millikan method of approximate solution of the boundary-layer equations. The method is applied to examples recently given by G. B. Schubauer and the calculated results are compared with those he obtained experimentally. Journal of the Aeronautical Sciences, January 1936, page 91.

Wind Tunnel Tests on a High-Wing Monoplane. C. B. Millikan, J. S. Russell and H. M. McCoy. Results of an investigation into the effect of the running propeller on the model at various attitudes and control-surface settings. The method given of specifying the power condition of the model in terms of the dimensionless parameter "angle of climb" is believed to be new and to have an important practical aspect. The experimental results show that for high-wing monoplanes similar to that tested, increasing power has a negligible effect on the airplane efficiency factor, a considerable destabilizing effect, and an important influence in increasing elevator effectiveness. Journal of Aeronautical Sciences, January 1936, page 79.

Wind Tunnel Tests on a High-Wing Monoplane with Running Propeller. J. S. Russell and H. M. McCoy. Results of research on the propulsive characteristics of two and three-bladed adjustable-pitch propellers extended to fairly large blade angles. A new type of wind-tunnel model is described which permits a study of the effects of a propeller mounted on a normal airplane model in medium-sized wind tunnels. Flight test data are also presented and compared with wind-tunnel results. Journal of the Aeronautical Sciences, January 1936, page 73.

Aerodynamic Theory, a General Review of Progress under a Grant of the Guggenheim Fund for the Promotion of Aeronautics. Brief reviews of book. Mechanical Engineering, February 1936, page 131. Brief abstracts of the (British) Aeronautical Research Committee Reports and Memoranda, dealing with aerodynamics, spinning, and a distribution method of stress analysis. Flight, Aircraft Engineer, January 23, 1936, page 7.

Airplane Design

Composite Aerodynamic Charts as Practical Aids to Calculations. W. F. Eade. Aerodynamic charts are given for use in calculating induced drag, induced angle of attack, and horizontal flying speed for a given lift coefficient, and the relationship of aspect ratio, span and wing area. Aero Digest, February 1936, page 54.

Engineering Problems in Aircraft Operation at High Altitudes. R. E. Johnson and R. F. Gagg. The possibilities of the typical modern airplane for high-altitude operation, and the restrictions of the power plant which prevent it from delivering its normal output at high altitudes are discussed. Improvements in the aerodynamic characteristics of the airplane are taken up, as well as changes in the power-plant design and the progress achieved in cruising operation at high altitudes within the limitations imposed by passenger comfort and safety. Further possible gains which may result from this trend are evaluated and the conclusion reached that the additional complications in structure and auxiliary apparatus required for high-altitude cruising with passengers probably do not warrant that type of flight operation except in the case of long non-stop flights over water or to avoid or make use of weather conditions on the flight route. A. S. M. E. Transactions, January 1936, page 1.

Flutter. M. Rauscher. Second installment which deals with the causes of and cures for flutter of cantilever wings, tail surfaces, and servo controls. The author discusses inter-aileron linkage, aerodynamic balancing and damping, resonance and non-regular flutter, eddy disturbances, and buffeting. Aviation, February 1936, page 26.

The Fool-Proof Aeroplane. Quotations from article by F. E. Weick (which appeared in the January issue of Aviation), with an editorial suggestion that the braking range of the glide-control device should be worked by a pedal. Aeroplane, January 29, 1936, page 125.

Great Britain. Brief reference to the future designs of transport planes, which were predicted by F. T. R. Hill, designer of the Westland-Hill Pterodactyl plane. Aero Digest, February 1936, page 80.

Load Factors and Stability. J. H. Crowe. Discussion of the importance of center-of-gravity position in load-factor determination, with results of an investigation to co-relate load factor and stability, the former being found by a step-by-step integration method. The characteristics appropriate to a modern high-speed single-seater fighter have been taken as an example. Aircraft Engineering, February 1936, page 39.

The Oscillating Wing. A. Guerin. Description of a design for an airplane with an oscillating wing, which was patented by the author and Corneloup in 1910. The plane has automatic transverse and longitudinal stabilization, elastic suspension of the wings, as well as animated wings. Les Ailes, January 16, 1936, page 4.

Seaplane Floats and Hull Design. M. Langley. Review of book which is said to be an elementary text presenting the necessary fundamentals of design. Reference is made to the tabulation of flying characteristics of English, American, French, and German seaplanes. U. S. Air Services, February 1936, page 28.

The Relative Safety of Multi-Engine Airplanes. K. Perkins. Quantitative determination for the relative safety of multi-engine airplanes as compared with single-engine ones on the basis of the mathematical probability of forced landings due to power-plant failure. Corrections are made for improved power-plant reliability, for the reduction of reliability due to overloading of remaining engines after failure of one, and for the increased probability of a first engine failure as the number of engines is increased. A generalized probability equation is developed. Journal of the Aeronautical Sciences, January 1936, page 103.

Special Planes for Amateurs. Flying characteristics of such a plane. Brief abstract of paper by O. C. Koppen presented before the S. A. E. Automotive Industries, January 25, 1936, page 123.

CONTROL SURFACES

Lateral and Directional Control. R. P. Alston. Discussion of the precise functions of the rudder and the ailerons in various conditions of flight indicating where each of them alone is adequate and where it may be necessary to have both. The need for the usual three controls in take-off and landing is emphasized. Aircraft Engineering, February 1936, page 31.

New Italian Contribution to the Problem of Lift-Increasing Devices. A. Silvestri. Reference to the new "Calm" type of trailing-edge flap which is the result of the combined efforts of Caproni, Longo, and Mattioli. Abstracted from L'Ala d'Italia, December 1935. Aero Digest, February 1936, page 38.

Lateral Stabilization. Description of the Bemberg lateral control system designed by an Argentine engineer and utilizing the vertical aerodynamic force to operate the ailerons. The system consists of a pair of "kites" linked to the lateral control in such a way as to operate the ailerons in the right direction under all conditions of flight. Criticisms are given in an editorial, page 31. Flight, January 9, 1936, page 38.

A Suggested Lateral Control Device for Use with Full-Span Flaps. H. B. Irving. A suggestion for a form of upper surface spoiler or flaps which is intended to eliminate the disadvantages found in those recently reported by Soulé and McAvoy in an N. A. C. A. report. Journal of the Aeronautical Sciences, January 1936, page 95.

Vertical Aerodynamics and the Bemberg Automatic Lateral Stabilizer. M. Victor. Description of the device and its advantages, as well as a discussion of Bemberg's research and flight-test results. Les Ailes, January 2, 1936, page 5.

LANDING GEAR

Retractable Undercarriages. G. H. Dowty. Historical review of retractable landing-gear design with examples of the latest practice including many American and British designs. This installment covers design requirements and retraction mechanisms. Aircraft Engineering, January 1936, page 12.

Retractable Undercarriages. G. H. Dowty. Conclusion of article describing manual-hydraulic, electro-mechanical, electro-hydraulic, engine-driven hydraulic and pneumatic-hydraulic systems of operation for retracting mechanisms. Emergency lowering mechanisms, safety locks, position indicators, and retractable tail wheels are also discussed. Aircraft Engineering, February 1936, page 33.

Airplane Performance

A Cabin Caterpillar. Brief discussion of a spinning-test accident to a Miles Nighthawk cabin monoplane which was built for Service training in instrument flying, with suggestions for the adoption of a method used in the United States for prolonged spinning tests. Aeroplane, January 29, 1936, page 132.

The Effect of Wing Setting on the Water Performance of Seaplanes. W. G. A. Perring. Abstract of (British) Aeronautical Research Committee Report and Memoranda No. 1656, discussing results of experiments in which the optimum wing setting of a seaplane is shown to be dependent upon the running angle of the hull and the aspect ratio of the wing structure. Aircraft Engineering, February 1936, page 56.

Seaplane Approval. Brief reference to results of flight tests on the Warner-powered Fairchild "24" seaplane. Aero Digest, February 1936, page 74.

Slots and Interceptors in Spins. R. P. Alston, S. B. Gates, H. B. Irving and A. V. Stephens. Description of an investigation to determine the effect of automatic slots in developing spins. Results obtained in flight tests are discussed, as well as those found with the N. P. L. spinning balance, and in the R. A. E. free spinning tunnel. Abstract of (British) Aeronautical Research Committee Reports and Memoranda No. 1660. Aircraft Engineering, February 19, 1936, page 56.

Spinning Experiments on a Model of the Bristol Fighter Aeroplane, Including the Effect of Wing Tip Slots and Interceptors. H. B. Irving, A. S. Batson and J. H. Warsap. Results of experiments made at the National Physical Laboratory with the new spinning balance. Abstract of (British) Aeronautical Research Committee Reports and Memoranda No. 1654. Aircraft Engineering, February 1936, page 56.

Static Stability Tests of Six Full-Scale Twin-Float Seaplanes. R. K. Cushing, A. S. Crouch and R. W. Angell. Results of experiments made to determine longitudinal and lateral metacentric heights and capsizing moments on the Vildebeest, III F, Osprey, Nimrod, Tutor and Atlas Twin-Float seaplanes. Abstract of (British) Aeronautical Research Committee Report and Memoranda No. 1653. Aircraft Engineering, February 1936, page 55.

The Water Performance of Seaplanes. W. G. A. Perring. Application of tank data to determine the effect of wind, variation of loading, or a change of air structure upon performance. Abstract of (British) Aeronautical Research Committee Reports and Memoranda No. 1657. Aircraft Engineering, February 1936, page 56.

Airplanes

The International Aircraft Exhibition at Milan. Discussion of the airplanes, propellers, and equipment of various countries which were exhibited at Milan. The Russian exhibit was said to be the most interesting, and a Russian amphibion observation plane for take-off from ships is described in which the wings, engine, propeller and rudder may be folded back for accommodation in a small amount of space. Mention is also made of a Russian all-metal high-wing monoplane sport plane with interesting metal profiles and a fuselage framework of single members flexibly joined. Details are given of a Russian monoplane for speed training which, powered with a 650 to 750-hp. radial engine, has a maximum speed of 467 km. per hour and a landing speed of 250 km. per hour. Reference is made to a Russian 12-cylinder 1150-to-1250-hp. Vee engine equipped with a supercharger, weighing 650 kg., and said to be the largest in-line aircraft engine in operation in the world. Automobiltechnische Zeitschrift, December 25, 1935, page 616.

BELGIUM

A Belgian Cabin Monoplane. Details of the Sabca three-seater cabin monoplane designed by Servais. Aeroplane, January 8, 1936, page 43.

The Fairey Monofox. Details of the latest military aeroplane built at the Belgian Fairey plant. It is said that this plane can be transformed in less than an hour from a single-seater fighter to a two-seater reconnaissance fighter or light bomber. The plane is derived from the famous Fairey Fox two-seater fighter or light bomber. Aeroplane, January 29, 1936, page 124.

CZECHOSLOVAKIA

The Avia 56 Transport Monoplane. Description of a plane designed for the rapid transport of mail, passengers, or express, and said to be transformable into a bomber or ambulance plane. The plane is powered by a Hispano-Suiza 12 Vbrs. 600-hp. engine and has a top speed of 360 km. per hour at 4000 meters. Rivista Aeronautica, January 1936, page 73.

Compact Comfort. Details of the design and flight performance of the Praga E. 114 Air Baby high-wing cantilever monoplane fitted with a 40-hp. Praga B engine. The leading edge of the wing and part of the windscreen may be folded back for entry into the cockpit. Flight, January 16, 1936, page 66-b.

FRANCE

France's New Air-Liners. Details of the Bloch 300 and Dewoitine D 620 passenger planes. Aeroplane, January 8, 1936, page 40.

French Airplanes. Specifications and four illustrations of the following airplanes: Amiot 143-M long-distance bomber; Breguet Wibault 283 T12 transport; Caudron "Luciole" C.272-4 and 5 two-place touring, C. 400 training "Goeland" C. 400 mail, "Fregate" C. 480 touring, "Pelican" C. 510 touring or ambulance, "Rafale" C. 530 sport, "Aiglon" C. 600 touring, and the "Simoun" C. 630 touring planes; Farman F. 221 bomber, F. 391 large touring, F. 392 touring, F. 403 touring, and the F. 431 transport planes; Latecoere 294 torpedo bomber, 301 trans-atlantic seaplane, 302 seaplane, and the 521 large seaplane; Loire-Nieuport Loire 46 pursuit, Loire 70 seaplane, Loire 130 catapultable observation, and the Loire 501 liaison and training amphibian airplanes; Potez 62 transport plane; Salmson "Phrygane" D2-T3 touring plane; and the S. P. C. A. 82 and 90 colonial planes. La Technique Aeronautique, No. 138, 1935, page 202.

The Laté-582 Flying Boat for the High Seas. Description of a Latecoere monoplane bomber which is designed for exploration over enemy fleets and for landing on the heavy seas. It is equipped with three Gnome-Rhone 14-krs. 740-hp engines and carries a load of 4000 kg for 1800 km. at a speed of 280 km. per hour. Les Ailes, January 2, 1936, page 3.

Morane-Saulnier Airplanes. Construction details of the 405 C pursuit plane and the 325 C 1 military plane are illustrated and explained. Revue de l'Armee de l'Air, December 1935, page 1433.

Reference to the recently tested Breguet-Dorand helicopter which is powered by a 350-hp Hispano-Suiza engine. Aero Digest, February 1936, page 78.

The Le O "H-43" Catapultable Seaplane. Description of a three-place shipboard observation seaplane which is equipped with a 650-hp Hispano-Suiza engine, takes off with a 1370-kg load and has a maximum speed of 222 km. per hour. Les Ailes, January 16, 1936, page 3.

Seventh Annual Review of French Aeronautical Products. The entire issue is devoted to specifications, descriptions, and construction details of the following French airplanes:—Bassou "Lutin", "Saphir", "Rubin" and "Heider"; Bernard "Charpentier" with unusual wing design; Bleriot Spad 222 experimental plane with unusual tail surfaces; Bloch 300 and 200 transport planes with reference only to the military types; Breguet-Wibault 670 T and 470 T transport planes; Breguet 460 M.5 "Vulture" multiplace fighter with illustrations of the gun turret; Caudron "Aiglon", "Luciole", "Rafale", "Fregate", "Pelican", "Simoun", "Typhon" and "Goeland" planes; Farman stratospheric equipment for the Farman 1001 stratospheric plane described and cabin arrangement illustrated, also brief descriptions of the Farman 221 and 222 bombers, and the Farman 224 transport plane; Fauvel A.V.3 and A.V.10 gliders; Gerin "Varivol" variable-surface wing; Hanriot H.180; Lamé rotating wing; Latecoere 582 and 521 "Lieutenant-de-vaisseau-Paris; Leyat glider; Levasseur P. L.201 seaplane; Loire et Olivier LeO.208. 259, and the LeO.H 43 military seaplanes; Loire-Nieuport Loire alO and 250 pursuit, 130 observation and 102 civil plane; Nieuport 140 attack bomber and 160 pursuit planes; Mauboussin 121; Mignet "Pou-du-Ciel"; Morane-Saulnier M.S.230 training, 345, 341 civil planes; Mureaux M.B 411 shipboard seaplane, 180 C.2, and 200 A.3; Oemichen flying machine (helicopter with a balloon suspended above it); Potez 62 high-speed transport, 54 multi-place fighter, 453 pursuit (with a diagram of control-surface controls); Romano R 80 training and R 90 pursuit seaplane; diagrams of the electric controls and other details of the Amiot 144 fighter; Dewoitine 333, 338, and 620; S. A. F. N. 1; S. F. C. A. Maillet 20-Lignel; and Zodiac airships. This section is followed by an advertisement section giving specifications in English and French for some planes, engines, and equipment. L'Aeronautique, December 1935, page 331.

GERMANY

Twin-Motored German Training. Two photographs of the Focke-Wulf FW-58 "Weibe" monoplane which has a top speed of 153 mph with two 240-hp Argus As.10C engines. The plane is designed for training pilots in flying by radio and instruments as well as for training machine gunners and bombers. Aeroplane, January 29, 1936, page 124.

A 254-mph Heinkel. Details of a fast new twin-engined ten-seater all-metal commercial monoplane based upon the Heinkel He 70, from which speeds of over 254 mph are expected when fitted with 880-hp units. Flight, January 16, 1936, page 63.

The Sailplane Competitions at the Wasserkuppe, 1935. S. Scott-Hall. Review of the Competition, with details of the Rhönsperber glider. Reference is made to the reorganization of gliding in Germany along military lines, and to gains from the intensive cultivation of this sport in Germany. Royal Air Force Quarterly, January 1936, page 27.

GREAT BRITAIN

The D. H. Dragonfly. Description of the new D.H. 90 twin-engined 5-passenger biplane, with particular reference to new structural methods employed on the wing and fuselage. Flight, January 23, 1936, page 78.

The Avro Anson. Long description of the R A F coastal reconnaissance monoplane which is equipped for long-range over-water flights. The plane is powered by two Siddeley Cheetah IX engines, each supercharged to give a maximum of 350-hp at 2425 rpm at 7300 ft, and has a top speed of 188 mph and range of 760 miles. Structure, armament, and location of equipment are illustrated and described in detail, especially the Armstrong-Whitworth rotatable gun turret. Aeroplane, January 29, 1936, page 127 (Photographs Jan. 15 issue page 61). Flight, January 30, 1936, page 116c.

D.H. 90. Description of the DeHavilland five-seater Dragon-Fly biplane which is powered by two 130-hp Gipsy Major engines, and has a cruising speed of 125 mph and a range of over 600 miles. Unusual construction features are illustrated and discussed. Aeroplane, January 22, 1936, page 108.

The Short "Scion-Senior" Monoplane. A. Frachet. Description of a ten-passenger monoplane which is equipped with four 90-hp Pobjoy "Niagara" engines. As a land plane it has a top speed of 225 km per hour. Les Ailes, January 9, 1936, page 3.

ITALY

Jona J.6 Biplane. Description of this new biplane with special reference to its arrangement for stability. The article states that the plane was constructed for the Ministero dell'Aeronautica for experimental purposes and is designed especially for instrument and night flying. Rivista Aeronautica, January 1936, page 43.

Events Abroad (Italy). Very brief reference to a new Italian standard medium bomber and the Italian military air exercises in July among discussions of other subjects such as civil aviation in Italy. Royal Air Force Quarterly, January 1936, page 126.

JAPAN

Two Japanese Airplanes. Specifications for the Kawasaki 92 single-seater land pursuit plane powered by a 500-hp B M W V-engine, as well as for the Nakajima P.1 single seater mail plane powered by a 420-hp Nakajima-Jupiter radial engine. Rivista Aeronautica, January 1936, page 78.

U. S. A.

8-Place Bimotored Lockheed 12 Series for Feeder-Line Operations. Description of an all-metal low-wing twin-engined Model 12-A plane which is similar to, but smaller than, the Electra but has better speed and all around performance. It has a top speed of 219 mph at sea level and 231 mph at 5000 feet. Aero Digest, February 1936, page 58. Aviation, February 1936, page 36.

Douglas D. S. T. Sleeplane. Further constructional details and performance figures are given for the new 16-place sleeper transport for service over the Southern transcontinental route. Aero Digest, February 1936, page 52. Aviation, February 1936, page 35. U. S. Air Services, February 1936, page 22.

Grumann F2F-1 Single-Seater Fighter. Description of one of the newest single-seater fighters for the Navy, which is powered with a 650-hp Twin Junior Wasp and has a maximum speed of 240-mph and a rate of climb of 2000 ft. per minute. Aero Digest, February 1936, page 56.

Kinner Invader. Description of the low-wing, twin-engined, six-eight place cabin plane to be powered with Kinner C-7 engines. It is expected to reach 210 mph top speed at 5000 feet, and to cruise at 190 mph at 75 per cent of the power at the same altitude. Aviation, February 1936, page 40.

Power Plants, Dimensions, Weights and Performance of American Aircraft. Two-page table followed by classification of American airplanes as to price and American engines as to horsepower. Photographs and specifications for each plane individually are also given. Western Flying, February 1936, page 32.

Stinson Model B Bi-Motor. B. D. DeWeese. Details of a new low-wing monoplane of the gull-wing type which is powered by two 260-hp Lycoming engines and accommodates six passengers. The plane has an estimated cruising speed of 152 mph at 1000 ft. and 160 mph at 6000 ft., and is designed for feeder line and industrial service. Aero Digest, February 1936, page 46; Aviation, February 1936, page 42.

Waco for 1936. Brief description of new equipment for the 1936 line of Waco aircraft. Aero Digest, February 1936, page 76.

The Military Vultee. Description and illustrations of the Vultee-II attack bomber as well as of the Consolidated P-30, Grumann F2 F-1 and Rasmussen II-a planes. Flight, January 9, 1936, page 42-c.

U. S. S. R.

Soviets Invent Glider that Packs in Suitcase. Brief reference to the Russian rubber glider which, when deflated, will go into an ordinary suitcase. Glider weighs 92 pounds, is 29 feet long, and has a wing span of 30 feet. Science News Letter, January 25, 1936, page 57.

Airships

Events Abroad (U. S. S. R.). Reference to a recent Soviet height record and to the newly constructed semi-rigid V.6 airship with which a dirigible air service between Moscow and Sverdlovsk will be started. Royal Air Force Quarterly, January 1936, page 129.

The Durand Committee Report. Brief discussion of the report of the Special Airship Committee of the Science Advisory Board which strongly endorses airships for commercial and military (Naval) purposes, and definitely recommends continuing a program of construction and use of airships. U. S. Air Services, February 1936, page 8.

Germany. Reference to a rumor that an order has been received from the United States for 10 power-driven semi-rigid airships, each being 330 ft. long and having a capacity of 616,000 c.f. cu. meters of gas. Airship, January-March 1936, page 65.

Goodyear Zeppelin Activities. Reference to a dummy airship for mooring tests, and to the Defender which was sold to the Navy for training purposes. Airship, January-March 1936, page 61.

Questions and Answers Concerning Airships. F. H. Gilmer. The answers given compare the relative value of the airship and airplane. United States Naval Institute Proceedings, February 1936, page 176.

TC-14 for Army. Details of the TC-14 coastal patrol airship which has been accepted by the Air Corps. Aero Digest, February 1936, page 64.

Ten Years is a Long Time. B. Jones. Analysis of transoceanic airplane flights and a comparison with those of the Graf Zeppelin. The airship is recommended for transoceanic services. U. S. Air Services, February 1936, page 17.

Metals

CASTING

New Compound Casting Method for the Production of Pistons, Especially "Heat-Resistant" Pistons. G. Gressenich. Description of a new method for casting Diesel-engine pistons which consist of two or more light-metal alloys of various characteristics. The compound casting of the alloys in one piece occurs simultaneously at a temperature advantageous for the gripping of the alloys, and in such a way that both parts retain their material characteristics. Automobiltechnische Zeitschrift, December 25, 1935, page 623.

HEAT TREATING

High-Carbon Gears Made Harder. Discussion of an improved method of hardening high-carbon gears which is said to offer certain advantages over the cyanide process. Abstract of paper by R. B. Schenck on "Metallurgy of Transmission Gears" which was presented before the S. A. E. Automotive Industries, January 25, 1936, page 125.

NON-FERROUS ALLOYS

Development of Aluminum for Aircraft. C. F. Nagel, Jr. Historical review of the development of aluminum to meet aviation's demands, and the results obtained. Aero Digest, February 1936, page 27.

Light Alloy Practice. H. G. Warrington. Discussion of the production of magnesium and aluminum alloys in both the wrought and cast conditions. The first article is devoted to magnesium alloys, and includes control during melting, effect of heat treatment on tensile strength, die casting, phenomena in forging and corrodibility. The second article takes up aluminum alloys and covers gating and running, melting and forging practice, die casting, extrusion of aluminum alloys, especially for aircraft construction, heat treatment, soldering and welding, and corrosion protection. Metal Industry, January 24 and 31, 1936, pages 136 and 160.

Protection of Aluminum Alloys. F. E. Pyne and W. L. Fink. Discussion of means for the protection of aircraft structures composed of thin highly stressed aluminum-alloy materials operating under the most severe salt-water conditions. Correct heat treatment, protective coatings and the anodizing process are described. The necessity for providing accessibility for inspection in the original design of an airplane structure is emphasized, and the use of a corrosion inhibitor is explained. Electric resistance spot and seam welding of Alclad is also taken up. Aviation, February 1936, page 30.

The Plastic Working of Metals. G. Sachs. Review of the more important theoretical knowledge obtained during recent years concerning the plastic working of metals. Alterations of the properties of metals due to hot and cold working are taken up, and strain hardening, the influence of speed and crystal orientation, resistance to deformation and energy consumed, tool design and friction, determination of the course of deformation, and the actual force relations are covered. Metal Industry, January 17, 1936, page 51.

1935 Corrosion Conference at Berlin. Abstracts of papers presented. Automobiltechnische Zeitschrift, December 25, 1935, page 625.

Cerium in a Light Alloy. Details of a new alloy called Ceralumin C, consisting of nickel and aluminum with small additions of cerium. It has been developed by J. Stone Company, London, and is a casting material containing iron (about 1.2 per cent) with aluminum as the main constituent. Heat treatment and properties are discussed. Abstracted from Machine Design, October 1935, page 29. Mechanical Engineering, February 1936, page 122.

The Influence of Pickling on the Fatigue Strength of Duralumin. H. Sutton and W. J. Taylor. Abstract of the (British) Aeronautical Research Committee Reports & Memoranda No. 1647, which in turn is an abstract of a paper published in Journal of the Institute of Metals, 1934, No. 2, page 149. Aircraft Engineering, January 1936, page 26.

Beryllium. W. Hessenbruch. Brief abstract from Metall und Erz, June 1935, page 234, referring to beryllium-copper characteristics. Mechanical Engineering, February 1936, page 117.

The Casting and Treatment of Magnesium Alloys. A. J. Murphy. Discussion of the composition and properties of Elektron A. 8 and A.Z.91 in the "as-cast" condition, and a review of die-casting methods, the corrosion resistance of magnesium-base alloys, and the applications of Elektron castings. Metal Industry, January 17, 1936, page 108.

The Possibilities of Extrusion. A. Reynolds. Discussion of the extrusion process, the variety of shapes produced, and the alloys which are adapted to this process. Aeroplane, January 8, 1936, page 39.

Quantitative Spectographic Analysis of Magnesium Alloys for Manganese and Silicon. J. S. Owens and T. M. Hess. The successful industrial application of spectographic methods to the analysis of these metals. Discussion of method which is employed by the Dow Chemical Company. Paper presented before the American Society for Testing Materials. Metal Industry, January 10, 1936, page 38.

PROTECTIVE COATINGS

The Structure of Metallic Coatings, Films and Surfaces. Brief abstract of report on discussion held by the Faraday Society. Journal of Scientific Instruments, January 1936, page 32.

The Trend of Recent Developments in Electrodeposited Coatings. A. W. Hothersall. Discussion of developments in the application of metallic coatings by electrodeposition, including improvements in the control of the properties of the deposits, in adhesion, and in the protective quality of electrodeposited coatings. Metal Industry, January 17, 1936, page 115.

Rustproofing and Paint-Adherence Technique Analyzed. F. P. Sprague. Description of methods for preventing the failure of paint on metal surfaces. The value of Deoxidine for cleaning steel before painting is explained. The author believes that the best protection is obtained by first plating steel with zinc and then converting this plated surface into a zinc phosphate so that the paint will adhere to it. He describes a chromate treatment known as Cromodine which gives a coating as elastic and as ductile as the steel itself, forms a perfect bond with paint, and is effective in increasing the life and durability of paint, lacquer or enamel finishes. S. A. E. Journal (Transactions) December 1935, page 459.

STEEL

Stainless Steels. H. Bull. Development and aeronautical application of the two types of non-corrodible steel, namely, the chromium-iron alloys and the chromium-nickel-iron alloys. Weld decay in the chromium-nickel type of stainless steel and its remedies are discussed. Tables show the mechanical properties resulting from the addition of increasing amounts of nickel to high chromium steels, the effect of cold rolling, the effect of reheating on toughness of "Duplex" Austenitic steel, scaling test results, and limiting creep values at various temperatures for several steels. Aircraft Engineering, February 1936, page 51.

Alloy Steels and Ferro-Alloys in 1935. J. C. Vignos. General review of developments in 1935. Heat Treating and Forging, January 1936, page 11.

Causes and Effects of Brittleness in Steel. C. L. Shapiro. Discussion of causes for the "temper-brittleness" of steel which results either from working at elevated temperatures, or from slow cooling from the above temperature to room temperature. It is concluded that "temper-brittleness" may be directly attributed to a precipitation phenomenon aided by transformation and crystallization, and that carbon is the direct cause. Heat Treating and Forging, January 1936, page 13.

Molybdenum Steels, Their Manufacture and Application. J. L. F. Vogel and W. F. Rowden. Very brief book review. Mechanical Engineering, February 1936, page 132.

Review of Iron and Steel Literature for 1935. E. H. McClelland. Very brief reviews covering metallurgy, testing, working, corrosion, and protective coatings, as well as other subjects. Heat Treating and Forging, January 1936, page 25.

The Scaling of Iron and Steel. Outline of research work carried out on the scaling of iron and steel and with reference to the need for further work in some directions. The mechanism of scaling and particularly the scaling of alloy steels are explained. Engineer, Metallurgist Supplement, December 27, 1935, page 82.

Stainless Steels. H. Bull. The discussion covers developments in stainless steel since 1912, remedies proposed for weld decay in the chromium-nickel 18/8 steel, and the problems to be faced in future developments. Abstract of paper presented before the Royal Aeronautical Society. Engineer, January 10, 1936, page 58.

Steel Made Stainless by Chromium-Alloy Plating. Brief announcement of a new process for the manufacture of "stainless" steel sheets and strips which was developed by the Cooper Products, Inc. The process consists in forming a coating of chromium alloy on steel bars in such a way that they can be rolled down into sheets or other shapes without removing the surface material. Automotive Industries, January 25, 1936, page 113.

Yoloy—Its Properties and Welding. F. J. Esslinger. Discussion of the properties of Yoloy, and the welding procedure necessary. Yoloy is a product of the Youngstown Sheet and Tube Company and is said to have a yield point almost double that of mild carbon-steel, high tensile strength coupled with ductility, a good degree of corrosion resistance, and excellent fatigue and impact characteristics. Welding Journal, January 1936, page 18.

WELDING

Arc Welding in Argon Gas. G. E. Doan and W. C. Schulte. Discussion of results obtained in arc welding in argon gas and a description of an apparatus for experimental welding at atmospheric pressure in controlled pure gas atmospheres. Three phenomena not previously associated with arc welding were observed in the tests in argon, namely, the impossibility of maintaining a stable arc in highly purified argon under ordinary conditions, the absence of all crater formation under pure iron in pure argon, and the absence of all observable "pinch effect" accompanying the detachment of the globules from the electrode wire. Welding Journal, January 1936, page 23.

Chemistry of Arc Welding is Discussed at Meeting of S. A. E. and A. W. S. Brief abstract of paper by F. R. Hensel, giving the physical chemistry of arc welding. Iron Age, January 23, 1936, page 54.

Forgeability of Welded Joints. H. Becker. Conclusions reached in an investigation to determine what influence forging has on the quality of welded joints and, in particular, how the heat of forging and the deformation in forging, the composition of the welding rod, and the character of the welding process react on the forgeability of the joint. Abstracted from Autogene Metallbearbeitung, July 1, 1935, page 193. Mechanical Engineering, February 1936, page 126.

Inspection of Welded Seams in Pressure Vessels. W. D. Halsey. Description of a method for investigating questionable fusion-welded vessels by trepanning plugs from the welded seams and etching these plugs to detect lack of fusion or slag inclusions. Welding Journal, January 1936, page 20.

Joint Welding Meeting. Brief review of papers presented before the joint meeting of the American Welding Society and the S. A. E., including "Physical Chemistry of Arc Welding" by F. R. Hensel and "Fundamentals of Spot Welding" by E. I. Larsen. Automotive Industries, January 25, 1936, page 129.

Monitoring a Welder with Mathematics. Details of a diode welder watcher by means of which welding machines may be adjusted so that the total heat energy developed in the weld during the welding cycle has the correct value. Electronics, January 1936, page 38.

Welding and Cutting High-Chromium Steels. W. J. Priestley. Discussion of the effect of chromium on the welding properties of steel, and a review of the problems which have been solved in the welding of these steels. The influence of columbium and titanium on their mechanical properties and the oxycetylene cutting of high-chromium steels are also described. Welding Journal, January 1936, page 14.

Welding Methods for the Non-Ferrous Metals. H. W. G. Hignett. Discussion of the metallurgical, thermal, and economic factors which influence the choice of welding process for non-ferrous metals. The processes covered include the oxyhydrogen and oxycoal gas, the oxacetylene, the carbon-arc, the metallic-arc, the atomic hydrogen, and the electric resistance spot and seam welding process. Metal Industry, January 17, 1936, page 92.

The Welding of the Alloy Steels. J. C. Hodge. Basic metallurgical principles governing the welding of alloy steels which are classified metallographically and by designation of the critical rate of cooling for hardening. The welding of low-alloy structural steels and of the stainless chromium-steels and irons is taken up. Welding Journal, January 1936, page 6. First part of the paper presented before the American Welding Society, and dealing in this issue with the welding of high-alloy steels. Iron Age, January 30, 1936, page 20.

Arc Welding. Brief review of "Procedure Handbook of Arc Welding Design and Practice" issued by the Lincoln Electric Company. Aero Digest, February 1936, page 86.

Welding Machines and Equipment. Brief description of new welding machines in the special Shop Equipment Review issue. American Machinist, January 29, 1936, page 112.

Welding of Alloy Steels. J. C. Hodge. Second part of article which outlines the metallurgical principles governing the welding of stainless steel and irons. Iron Age, February 13, 1936, page 52.

Non-Metallic Materials

Glopane for Aeroplanes. Reference to a compound which is said to prevent the formation of steam and hoar-frost on motor-car wind screens, within or without, and to work as well on windows of plastic materials as on windows of glass. Aeroplane, January 22, 1936, page 114.

New Optical Material Eliminates Headlight Glare. Advantages and applications of Polaroid which resembles a sheet of glass but has the ability to polarize the light which passes through it and to cut off glare without obscuring the view. Science News Letter, February 1, 1936, page 77. Business Week, February 8, 1936, page 14.

Plexite Safety Glass. Details of a safety glass developed by the American Window Glass Company which is flexible enough to dent or yield on impact, yet has sufficient strength to resist penetration. Aero Digest, February 1936, page 61.

Production of Asphaltum and Stearine Pitch Lacquers and Paints. Influence of bitumen on the oxidation of the oil and production methods. Paint and Varnish Production Manager, February 1936, page 28.

Rubber in Paints and Varnishes. Discussion of the improved properties obtained with paints containing a small amount of rubber. Formulas are given for rubber paints. The preparation of 50 per cent modified rubber solution, known as Solution "B", and inventions for "improvements in and relating to rubber derivatives suitable for paints and varnishes," are described. Paint and Varnish Production Manager, February 1936, page 12.

Plaskon. Details of plaskon which is a heat-hardening plastic for hot-welding, compounded from nitrogenous resins, fillers, pigments, mold lubricants, and softening agents. Moldings may be joined to one another by being cemented, by pressure fits, or rivets or screws. Physical properties are given. Abstracted from Machinery, November 1935, page 169. Mechanical Engineering, February 1936, page 116.

Du Prene Adopted by U. S. Air Corps for Fuel and Oil Lines. Brief reference to the use of a synthetic rubber as a standard material for lining fuel and oil line connections and for radiator connections on airplanes, the latter where engines are water cooled. Automotive Industries, February 1, 1936, page 145.

Stress Analysis and Structures

Form Factors for Structural Shapes. R. Contini. A method is given for readily obtaining the section properties of some of the shapes more commonly used in airplane structures, and is intended to serve as a basis for development to use with a greater variety of sections. Aero Digest, February 1936, page 34.

Great Circle Engineering. Discussion of the problems arising in the production of a monoplane of really high aspect ratio (abstracts from H. L. Hibbard's paper before the German Research Institute for Air Transport entitled "Development and Trends in High-Speed Aircraft") and a description of the Vickers Wallis geodetic construction in which the material is placed as close to the outer surfaces as possible but is used in members of such form that the full strength of the material is developed. Reference is made to the Vickers Wellesley planes with this type of construction with have been ordered in quantity for the Royal Air Force. Aeroplane, January 15, 1936, page 73.

The Strength and Flexibility of Corrugated and Creased-Bend Piping. Lieut. R. W. Davison, U. S. N. First of a series discussing results of an investigation which was undertaken to determine the relationship between load and deflection for various shapes of corrugated and creased-bend pipes in order to establish their flexibility relative to smooth-walled pipe; to determine the endurance properties of corrugated and creased-bend pipes under cyclic stressing; to develop methods for measuring strains induced in these pipes under load; and to derive values for the safe working stresses for these pipes for the purpose of piping system design. Precautions in manufacturing are included in this issue. Abstracted from dissertation submitted to the Advisory Board of Johns Hopkins University. Engineer, January 24, 1936, page 103.

Geodetic Construction. Explanation of the Vickers-Wallis system of a geodetic structure for airplanes, which combines lightness with great strength and torsional rigidity. Advantages of concentrating material, and of balancing tension against compression, as well as production problems are discussed. Flight, January 16, 1936, page 66d.

On the Transverse Vibration of a Square Plate with Four Clamped Edges. S. Tomotika. Calculations of the frequency of the fundamental mode of vibration of a square plate, the method of treatment being similar to that used by Prof. G. I. Taylor in his paper on the statical problem of buckling under edge thrusts of a rectangular or square plate clamped at its four edges. Abstract of Tokio Imperial University, Aeronautical Research Institute, Report No. 129, September 1935. Aircraft Engineering, January 1936, page 24.

Stress Analysis by X-Ray Diffraction. C. S. Barrett and M. Gensamer. Mathematical analysis of the problem of determining stresses in a metal by X-ray diffraction, including various methods for the determination of uni-axial stresses or the sum of two principal stresses in the plane of the metal surface, as well as the problem of determining the two principal surface stresses individually. By the methods proposed these stresses may be found with an accuracy calculated to be of the order of 1300 lb/sq.in. for iron and 320 lb/sq.in. for duralumin. Camera design for the determination of the principal stresses individually, exposure technique, and applications are discussed. The method of stress measurement applies to the surface stresses in a body which is under a three-dimensional stress system. No assumption that the stress remains constant throughout the thickness is necessary as in photo-elastic studies. It measures the internal stresses as well as those resulting from external loading, and is said to be applicable to a completed structure during service without removal of the service load and without damage to the structure. It measures the difference in the principal stresses as well as the sum. Physics, January 1936, page 1.

Two-Spar Cantilever Wings. Second part of article which describes a method for determining the stresses in spars and skin. The method employs the relationship between the slope of the spars and the torque in the skin for the evaluation of the whole of the stresses in the skin and spars, giving incidentally the relative slope of the spars. Flight, Aircraft Engineer Supplement, January 23, 1936, page 3.

What is the Future of Metal Construction? Brief discussion of the resistance to fatigue found in this type of aeronautical construction. Abstracted from L'Echo des Ailes. Les Ailes, January 2, 1936, page 5.

Engine Design and Research

Aeronautical Research. Editorial comments on the Report of the British Aeronautical Research Committee for the year 1934–35. Particular reference is made to an automatic mixture control device developed at the Royal Aircraft Establishment which reduced fuel consumption from 14 to 30 per cent. Results obtained in research on carburetor freezing prevention, reduction of weight-horsepower ratio, the N. P. L. compressed-air tunnel, "geodetic" construction, flutter prevention, and noise abatement are also discussed. Engineering, January 24, 1936, page 96.

The Case of the Aircraft Diesel Engine. Discussion of the methods followed in aircraft Diesel-engine research, the difficulties which were overcome, and the results obtained. The author describes three types of test apparatus which proved effectual for securing data regarding high-speed oil-engine performance. Aero Digest, February 1936, page 48.

Perfect Circle Expander Ring of Radical Design. Details of a new expander type piston ring which utilizes a series of independent double-leaf-spring units equally spaced on a carrier band. Automotive Industries, February 8, 1936, page 194.

Thermodynamics of Volume Distribution. R. L. Sweigert. Discussion of the effect of volume distribution of the combustion chamber upon performance from the viewpoint of thermodynamics. The essentials of a good combustion chamber, time of combustion, and change in volume due to expansion of the burned charge are taken up. Abstract of paper presented before the S. A. E. Oil and Gas Journal, February 6, 1936, page 26.

Engines

Aircraft Engines at the Milan Exhibition. F. Wittekind. Description of engines exhibited with special attention to the Italian products. A table is included which gives specifications for the twenty-four aircraft engines exhibited covering five Calfa Romeo, three C. N. A., four Fiat, one Fuscaldo, two Hirth, three Isotta Fraschini, five Piaggio, one Walter, and three Russian air-cooled engines, and one Russian (M-34), three Fiat, and three Isotta Fraschini water-cooled engines. Automobiltechnische Zeitschrift, December 25, 1935, page 620.

Ensuring Safety. Brief reference to an overload test of the Bristol Pegasus III which was operated for 370 hours at a continuous output of 800 bhp at 2300 rpm. Aeroplane, January 8, 1936, page 56.

Double Engines of 2,000-hp for the 80-Ton Latecoere. Reference to a rumored Latecoere 80-ton plane which will be fitted with four groups of two engines each and developing a total of 8000 hp. Also a brief discussion of the possibilities of the double arrangement. Les Ailes, January 2, 1936, page 3.

Ford Experimenting with V-8 for a Light Airplane. Brief reference to model. Automotive Industries, January 18, 1936, page 71.

Freezing in Carburetors. A. Swan. Discussion of the practical considerations arising from an investigation to determine the conditions under which ice is formed and to find a means for the prevention or removal of ice in carburetors. A carburetor freezing indicator is described and three methods of prevention are taken up, including the use of jacket heat, intake heat, or an ice inhibitor such as alcohol. Aircraft Engineering, January 1936, page 3.

320 hp. and 450 hp. De Luxe Equipped Whirlwinds. Description of two Whirlwinds designed to give the private owner and operator of small and intermediate commercial transports the equipment needed for radio and navigation instruments. The engines are provided with special drives for the operation of generators, a vacuum pump for the actuation of navigation instruments, a mechanism for hydro-controllable propeller, as well as complete radio shielding, full-pressure baffling, automatic valve-gear lubrication, and an alternate mounting diameter. Aero Digest, February 1936, page 40.

American Aircraft Engines. Photographs and specifications for more than fifty aircraft engines. Western Flying, February 1936, page 74.

New Kinner Engine. Description of the SC-7 seven-cylinder radial aircraft engine which develops 370 hp at 1900 rpm at 5000 feet. Aviation, February 1936, page 46.

The Rateau-Potez 12 As Engine with a Turbo Compressor. Description of a 12-cylinder water-cooled 350-hp engine with a supercharger driven by an exhaust-gas turbine. The cylinders are arranged in two opposite groups of six each in a horizontal plane so that the engine may be mounted within the wing or at its leading edge with either direct or remote drive to the propeller. From L'Aeronautique No. 193, 1935. Rivista Aeronautica, January 1936, page 78.

Renault. Very brief reference to a new 12-cylinder inverted V supercharger air-cooled Renault engine which was successfully tested for the French Army. It develops 450 hp at 3750 meters and at 2500 rpm, and weighs 356 kg. Les Ailes, January 16, 1936, page 4.

M. I. T. Begins Study of Two-Cycle Air Engines. Plans for research on aircraft engines, to be undertaken at M. I. T. with the aid of N. A. C. A. funds. The two problems to be studied cover the adaptation of the two-cycle engine to aircraft use with particular reference to the scavenging problem, and the dynamic characteristics of the induction systems of conventional internal-combustion engines. Automotive Industries, January 25, 1936, page 115.

Problems in Engine Research. R. S. Capon. Survey of recent progress in engine research with deductions for future trends. The author, who is Superintendent of Research at the Royal Aircraft Establishment, refers principally to developments in sleeve valves, replacement of the carburetor by a system of gasoline injection, decrease in interest in the Diesel engine, automatic mixture control, cowled radiators, two-speed compressors, multi-stage compressors, and exhaust-gas turbines. Abstract of paper presented before the D. V. L. and V. L. F. Conference in Berlin. Aircraft Engineering, January 1936, page 10.

Swing of the Pendulum. Brief reference to high-powered engines developed for the French fighters as compared to those powering British fighters. Flight, January 16, 1936, page 57.

Accessories

Carburetor Ice Eliminator. Details of an exhaust collector which serves also as a heating medium for the carburetor air intake line. The device is a development of Eastern Air Lines and the Pollak Manufacturing Company. Aero Digest, February 1936, page 61.

Italian Carburetor Uses Alcohol as Motor Fuel. Brief reference to a special carburetor for automobiles which is said to use ordinary denatured alcohol with satisfactory results. Automotive Industries, February 1, 1936, page 146.

Valve Gear Lubricating Pump. Details of an automatic valve-gear lubricating pump which the operator of Whirlwind and Cyclone engines may utilize in place of the control valve on his production model. Aero Digest, February 1936, page 61. Aviation, February 1936, page 46.

The Bryce-Belfrost Coupling. Details of an automatic device for fuel-injection pumps. Automobile Engineer, January 1936, page 12.

For Oil and Fuel. Details of the Tecalemit engine fuel pump designed so that it may be mounted in an inverted position. The Tecalemit oil filter, which is said to have an extremely low back-pressure figure, is also briefly described. Flight, January 16, 1936, page 70.

Fuel and Oil Tank Construction. P. J. Billig, Jr. A half-page article with charts of bending tests. Aero Digest, December 1935, page 32.

International Standard Association Congress. Resumé of action taken by the Aeronautics Committee at a meeting in Milan, regarding tires and rims, pipes, and pipe joints, spark plugs, distinctive colors for pipes, turnbuckles, streamlined wires, and the direction of rotation of engines and propellors. La Technique Aeronautique, No. 138, 1935, page 199.

A New Oil Filter. Description of the Smith oil filter. Automobile Engineer, January 1936, page 30.

Combustion

Dissociation of Combustion Gases and Its Influence on the Efficiency of Carburetor and Diesel Engines. H. Kühl. Long abstract of that part of the investigation which deals with the dissociation of the gases. Deviation between theoretical and experimentally determined values, and the work of Eucken and Mücke are discussed. Equations are given for the formation of hydroxyl, for the dissociation of water, for the break down of hydrogen and oxygen into their atoms, for the formation of nitrogen oxide, and for the water-gas reaction, all of which the author considers of great importance in addition to the break down of carbon dioxide into carbon monoxide and oxygen, and of water vapor into hydrogen and oxygen. Abstracted from Forschung auf dem Gebiete des Ingenieurwesens, July-August, 1935. Mechanical Engineering, February 1936, page 120.

J. S. Diagrams for Combustion Gases of Correct and Weak Mixtures. K. Tanaka and S. Awano. Eight sheets of total heat-entropy diagrams as well as some auxiliary diagrams for use with internal-combustion engines, especially gasoline engines. Abstract of Tokio Imperial University Aeronautical Research Institute, Report No. 128, September 1935. Aircraft Engineering, January 1936, page 24.

Relation of Exhaust Gas Composition and Air-Fuel Ratio. B. A. D'Avella and W. G. Lovell. Determination of the air-fuel ratio which is supplied to an engine, the exhaust gas composition being found by chemical analysis. Abstract of paper presented before the S. A. E. Oil and Gas Journal, January 23, 1936, page 42.

Cooling

N. A. C. A. Study of Radial Air-Cooled Engine Cowling and Cooling. D. H. Wood and C. Kemper. Description of a recent N. A. C. A. investigation to obtain sufficient data to place the design of cowling on a rational basis. Results are given which were obtained from model tests of cowlings in a wind tunnel to determine the effect of front and rear openings and of inner and outer lines of the cowling on the quantity of air flowing through the cowling, the pressure drop, and the drag. Tests are described which were made with a single-cylinder engine to determine the quantity of air and the pressure drop required for satisfactory cooling, as well as the check tests on a radial engine in the 20-ft. propellor-research tunnel. The method proposed for designing the N. A. C. A. cowling is outlined. S. A. E. Journal (Transactions), December 1935, page 441.

Wind Tunnel Investigation of the Cooling of an Air-Jacketed Engine. A. S. Hartshorn. Data given in the report are said to be sufficient to estimate the total excess power required to provide a given rate of heat dissipation for an air-jacketed installation. The tests showed that, with a cowled system such as a Townend ring, the power required for a given rate of heat dissipation could be almost halved by adding suitable rear guide vanes. Abstract of (British) Aeronautical Research Committee Reports and Memoranda No. 1641. Aircraft Engineering, January 1936, page 26.

Cylinders and Pistons

Campbell, Wyant Show S. A. E. Members New Steel Piston. Brief reference to a new moly-silicon alloy steel piston comparable in weight to aluminum pistons but said to produce less friction horsepower and better cooling. Automotive Industries, January 18, 1936, page 75.

Cylinder-Wear Measurements. Results obtained by a method of continuous cylinder-wear measurement. Abstract of paper presented before the S. A. E. by G. D. Boerlage and B. J. Grovesteyn of the Shell Petroleum Corporation. Automotive Industries, January 25, 1936, page 124.

Cylinder Wear on Aero Engines. Discussion of data gathered from aircraft manufacturers and operators on the subject of piston-ring and cylinder wear in aircraft practice. Brief abstract of paper presented before the S. A. E. by R. Insley. Automotive Industries, January 25, 1936, page 128.

Effect of Gas Pressure on Piston Friction Diagnosed. Results of experiments made at M. I. T. Abstract of paper by M. P. Taylor presented before the S. A. E. Automotive Industries, January 18, 1936, page 87. Oil and Gas Journal, January 23, 1936, page 42.

Sticking Pistons—Cylinder Life. Results of research on cylinder wear and piston-ring sticking tendencies in automobile, bus, and aircraft engines. Abstract of paper presented before the S. A. E. by C. M. Larsen, W. G. Ainsley, and M. Fairlie of the Sinclair Refining Company. Also abstract of paper by C. G. Williams on cylinder-wear research which was carried out by the Institution of Automobile Engineers. Automotive Industries, January 25, 1936, page 122.

Fuel Consumption

Aero Fuel Economy. Details of an automotive exhaust-gas analyzer for aircraft use, which will give the pilot visual evidence of the effect of a change of mixture ratio on power-plant performance. A method is referred to by means of which the mixture strength furnished by the carburetor is automatically controlled by permitting the variations in the density of the carburetor air supply to regulate the fuel flow. Abstract of paper presented before the S. A. E. by R. W. Young of Wright Aeronautical Corporation. Automotive Industries, January 25, 1936, page 127.

Fuel Consumption. A. Taub. Discussion of factors entering into fuel consumption and of the improvements which have resulted in greater fuel economy. Abstract of paper presented before the S. A. E. Oil and Gas Journal, January 23, 1936, page 42.

MAINTENANCE

The Electrolytic Cleaning of Exhaust Valves. S. D. Heron, G. Calingaert and F. J. Dykstra. Description of equipment and method which was developed in the research laboratories of the Ethyl Gasoline Corporation for removing deposits on exhaust valves without removing any of the underlying metal. S. A. E. Journal, December 1935, page 19.

SUPERCHARGERS

Supercharging. Abstract of four papers on supercharging, which are devoted respectively to aircraft engines, marine oil engines, touring car engines, and supercharging in general. In the paper dealing with the application of supercharging to aircraft engines, A. H. R. Fedden gives the factors upon which supercharging depends, and refers to results of research by the Bristol company. He prefers the mechanically driven centrifugal-fan type of supercharger and believes the exhaust turbo-compressor has been unduly condemned, inasmuch as this type provides an efficient silencing and flame-damping system for the engine. The paper by R. H. Ricardo takes a position against supercharging. Abstracted from Institution of Mechanical Engineers Proceedings, Vol. 129, 1935, page 197. Mechanical Engineering, February 1936, page 117.

TESTING APPARATUS

Proving Connecting Rods. Description of the Avery connecting rod prover designed for the balancing of both ends of a connecting rod simultaneously. Aircraft Engineering, January 1936, page 21.

VIBRATION PREVENTION

Anti-Vibration System for Aero Engine Explained. Advantages of a pendulum vibration-absorber device for preventing torsional vibration of the rotating system in a radial aircraft engine. Operation of the device is said to be independent of the vibration characteristics of the system to which it is attached, and dependent only on the nature of the torque impulses. Difficulties which were overcome in its application to a Wright Cyclone are discussed. Abstract of paper by E. S. Taylor presented before the S. A. E. Automotive Industries, January 18, 1936, page 80.

Fuels

Alcohol Fuel Mixture. Abstract of report from the Austrian Petroleum Institute of Vienna. Automobiltechnische Zeitschrift, December 25, 1935, page 627.

Fuel Requirements for Diesel Engines. The significance of the ignition characteristics of Diesel fuels and the results of laboratory and service tests. Abstract of paper by J. R. MacGregor presented before the S. A. E. Automotive Industries, January 18, 1936, page 83.

Fuels Are Investigated. Report of the Volunteer Group for Compressor-Ignition. Fuel Research covering problems investigated. Abstract of paper presented before the S. A. E. Automotive Industries, January 25, 1936, page 124.

Knock Testing Diesel Fuels. T. B. Rendel. Discussion of the mechanism of combustion in the solid-injection high-speed compression-ignition engine, the importance of the ignition quality of fuel in controlling the delay period, and experiments with a modified C. F. R. engine. Abstract of paper only. S. A. E. Journal, December 1935, page 35.

Lag of Ignition is Utilized to Determine Cetane Rating of Diesel Fuel Oils. P. H. Schweitzer and T. B. Hetzell. Description of a fixed-ignition lag method by means of which Diesel fuels may be rated in the same order as they behave in an oil field engine. Long abstract of paper presented before the S. A. E. Oil and Gas Journal, January 23, 1936, page 36.

Note on the Soviet Experiments in the Refining of Gasoline. M. Precoul. Description of experiments in Russia in refining aviation gasoline from Grozny and Bakou. L'Aerophile, December 1935, page 372.

The Story of Ethyl. Discussion of the influence of high-octane gasoline on Engine Design. Abstract of paper by F. R. Speed presented before the S. A. E. Automotive Industries, January 25, 1936, page 126.

The Utilization of Alcohol as a Coolant Fuel in Airplane Engines. J. Tourkia. Results obtained in flight tests with additions of "anthene" to gasoline-alcohol, heavy-oil and Djavol fuels. "Anthene" is described as a super-lubricant adapted to alcohol, which when introduced into a fuel in small quantities, stabilizes the gasoline-alcohol mixture, homogenizes the air-fuel mixture, atomizes it, and transforms it into a vapor for complete combustion with a marked increase of thermal efficiency and decrease in consumption. It is said that due to its antidetonating qualities, fuels of a higher octane index may be used, and that, due to its solubility in alcohol, lubrication of the cylinders takes place in its presence. It is also said to be non-corrosive. L'Aerophile, December 1935, page 368.

Hydrogen as an Auxiliary Fuel for Aircraft. Results of tests to determine the quantity of hydrogen that can be burned in a compression-ignition engine when inducted with the inlet air, the combustion characteristics of mixtures of hydrogen and fuel oil, and the suitability of exhaust gases for water recovery. Abstract of N. A. C. A. Report No. 535 by H. C. Gerrish and H. H. Foster. Automotive Industries, February 1, 1936, page 164.

Study of Gasoline Treating Reagents Shows Need of Improved Methods. C. Wirth, III and G. B. Murphy. Discussion of gasoline sweetening reagents now used in commercial practice and the resulting deleterious effect on color, susceptibility to gum inhibitors and tetraethyl lead, stability, and octane number of the finished product. Oil and Gas Journal, February 6, 1936, page 28.

Lubricants

Film-Lubrication Theory and Engine-Bearing Design. E. S. Dennison. Film-lubrication theory data are adapted to the design of bearings for reciprocating engines, particularly for the case of the high-speed internal-combustion engine. Suitable corrections for end leakage in short bearings have been incorporated and results presented in the form of design charts. Published experimental data are correlated with reference to the theory. The flow of oil in pressure-fed engine bearings is taken up, the oil being considered as a coolant as well as a lubricant. A. S. M. E. Transactions, January 1936, page 25.

Lubrication of Aircraft Engines. E. L. Bass. Abstract of article entitled "Economics of Aircraft Engine Lubrication" which appeared in Shell Aviation News, July 1935. The author gives calculations for determining when it is more economical to concentrate upon reducing the oil consumption rather than upon increasing the overhaul period. Aero Digest, February 1936, page 49.

Atlantic Completes Severe Road Tests on Motor Oil Containing Additive. T. G. Delbridge. Results obtained in tests of an "alloy" oil which will stand 15,000 lb. per sq. in. pressure, and contains 99 per cent petroleum and 1 per cent non-chlorinated ester of phosphoric acid. Use of the oil is said to reduce wear in an average high-compression engine by 40 per cent at the point of most severe wear. Oil and Gas Journal, January 16, 1936, page 28.

Colloidal Graphite. Brief reference to booklet on the mechanism of colloids and colloidal graphite in particular, which is distributed by Acheson Colloids. Automotive Industries, January 25, 1936, page 132.

Fundamental Chemical and Physical Forces in Lubrication. G. L. Clark, E. H. Lincoln and R. R. Sterrett. Brief abstract of paper presented before the American Petroleum Institute. Oil and Gas Journal, January 23, 1936, page 42.

Propellers

Induced Velocity By Helical Vortices. S. Kawada. Calculations for finding the induced velocity for a propeller with uniform distribution of circulation along the radius. Journal of the Aeronautical Sciences, January 1936, page 86.

The "Slinger-Ring" De-Icer for Propellers. P. T. W. Scott. The development of the propeller de-icer is described with details of its design, installation, and the fluid used. Aero Digest, February 1936, page 42.

Variable Pitch Propeller Automatically Controlled by a Smaller Propeller. Description of a new Ratier automatically controlled variable-pitch propeller which has been tested on the Nieuport 125 and will be used on all the new French pursuit planes, the Morane 12-Y, the Nieuport 12-X, the Loire 14-Ha, the Dewoitine 12-Y, and the Mureaux-Salmson. The pitch of the large three-bladed propeller is controlled by means of a smaller two-bladed propeller which is located in front of it, is braked, and turns at slower speeds than the larger one. Advantages of this type of propeller operating with a Hispano 12 Ycrs are given. Les Ailes, January 16, 1936, page 4.

Reaction-Propulsion

Rocket Propulsion by Means of Explosives. L. Damblanc. Long description of the author's systematic experimental studies of the auto-propulsive rocket and the results obtained. Abstracted from L'Aerophile, Nos. 7 and 8, 1935. Rivista Aeronautica, January 1936, page 87.

Acoustics

The Sperry Noise-Reducer for Aircraft. Description and patent drawings of a double-walled cabin with the ventilation actuated by motor and exhaust. L'Aerophile, October 1935, page 310.

Airport Equipment

Metal Vapor Lamps. Description of the properties, installation, and practical applications of the sodium-vapor and mercury-vapor lamps. (Possibly applicable to airport lighting.) V. D. I., December 21, 1935, page 1521.

Wind Pressures on the Akron Airship Dock. K. Arnstein and W. Klemperer. Results of wind-pressure-distribution tests on the hangar and a comparison with those obtained in model tests in the New York University wind tunnel. Journal of the Aeronautical Sciences, January 1936, page 88.

All Gas, No Water. Details of a new automatic foot-valve developed by the Swift Lubricator Co. to prevent pumping water out of the bottom of gasoline storage tanks. Aviation, February 1936, page 53. Aero Digest, February 1936, page 60.

Beating the Bounds. Description of the Boundary Bollard airport boundary light. This consists of a three-foot pillar surmounted by a red lamp and supported by guy wires which are spring-tensioned up to a 40-lb. pull, each wire having a weak copper link which will break with a 50-lb. strain. Aeroplane, January 16, 1936, page 76.

Armament

The Oerlikon Model FF Gun. Description of a German 20-mm gun and a method of mounting it inside the wing of an airplane. A diagram and photograph show the gun mounted in the wing of a P. Z. L. pursuit plane. Abstracted from Flugsport, No. 20. Rivista Aeronautica, January 1936, page 74.

To Benefit Marksmanship. Details of the Armstrong-Whitworth gun turrets which were fitted in the nose and tail of the A. W. XXIII bomber-transport and amidships on the Avro Anson coastal reconnaissance plane. Its purpose is to protect the gunner and to enable the gun to be trained with a minimum of physical effort. Flight, January 23, 1936, page 91.

Ice Prevention

The Prevention of Ice Accretion. B. Lockspeiser. Comparison of the thermal, mechanical, and chemical methods for preventing the accretion of ice on airplanes. Meteorological conditions favorable to ice formation are also included. The construction of an anticer is described which provides a porous leading edge on the wing which can be saturated with a liquid possessing a strong effect in depressing the freezing point of water. Requirements of a liquid for this purpose and the results of test flights at the Royal Aircraft Establishment are discussed. Application of the chemical method to propellers is also referred to. Royal Aeronautical Society Journal, January 1936, page 1. Discussion page 14.

Instruments

AIRCRAFT

Barometric Altimeters Not to be Trusted in Storms. Discussion of incidences when the barometric altimeter readings were not reliable in a storm. Bulletin of the American Meteorological Society, December 1935, page 320.

Developments in the Electrical Industry During 1935. J. Liston. Brief reference to developments in aircraft instruments in the section devoted to meters and instruments. General Electric Review, January 1936, page 58.

Gyroscopic Indicators. Brief description of a venturi arrangement for gyroscopic indicators, which was recently patented by Schilovsky and is constructed by Cooke-Troughton and Simms. Les Ailes, January 2, 1936, page 4.

The Dubois-Laboureur Sonic Altimeter. Description of the C. E. M. A. automatic sonic altimeter which has been successfully tested by the French Air Ministry. The height of the airplane above the ground is determined from the interval between the signal from the device and the reception of its echo. Les Ailes, January 16, 1936, page 5.

Flying in the Clouds. Very brief criticism of the method of checking altimeters in flight by using airport barometer readings reduced to sea level according to "standard atmosphere." Bulletin of the American Meteorological Society, December 1935, page 321.

Fuel Flow Signal. Description of an automatic signalling device developed by the Steel Products Engineering Company to warn the pilot of interruption in the flow of fuel from tanks to pump. Aviation, February 1936, page 53.

TESTING

Calibration of Small Venturi Meters. J. J. Mikita. Description of apparatus and results obtained in the calibration of small venturi meters for viscous liquids over the flow and viscosity range encountered in engines. The calibration was undertaken. Instruments, January 1936, page 2.

Cathode Ray Recorder "Remembers" by Means of Fluroescence Delay. Details of an unusual type of pre-recording oscillograph which records not only a current or voltage impulse but also the current or voltage which preceded the impulse. The study of lightning flashes. Electronics, January 1936, page 36.

New Instruments. Details of new devices for measurement, inspection, testing, metering and automatic control. Instruments, January 1936, page 24.

The First Line of Insurance. List of equipment carried by automobile by the staff of the British Aeronautical Inspection Directorate for use in the inspection of passenger-transport airplanes for the renewal of Airworthiness Certificates. Aeroplane, January 15, 1936, page 83.

Incline Plane Tester. Brief description of the Scott incline-plane testing machine of the motor-driven autographic-recording type for tensile and elongation tests of tire cord and other materials requiring a machine capacity not exceeding 50 pounds. India Rubber World, February 1, 1936, page 45.

Miscellaneous Equipment

Rubber Safety Equipment. Very brief reference to a Soviet experiment in which a deflated rubber boat attached to a parachute was thrown from an airplane, after which three men jumped from the plane with parachutes, each inflating a rubber lifeboat in his descent. Upon reaching the water they inflated the rubber boat and rowed away. India Rubber World, February 1, 1936, page 27.

Parachutes

The Parachute Jumper. A comprehensive article which deals with the general conditions placed upon a good parachute, calculation of acceleration, results of medical studies of the neuropsychological reactions of high-altitude parachute jumpers (with approval of the decision made by the French Air Ministry to set up a military school for parachute jumpers), and a theoretical study of parachute technique with formulas and graphs of interest to both designers and user. L'Aerophile, December 1935, page 357.

Photography

Apparatus Notes. Details of the new giant nine-lens Fairchild aerial camera for the U. S. Coast and Geodetic Survey. The camera weighs 305 lb. loaded, has a record focal length for a multi-lens aerial camera of 8¼ inches, and photographs an area of 600 square miles from an altitude of 30,000 feet. Journal of the Aeronautical Sciences, January 1936, page 107.

The Electron Telescope. Zworykin and Morton. Description of the electron telescope and its latest applications such as translating infra-red light directly into visible light without the necessity of any intervening photographic process. Abstract of paper presented before the American Association for the Advancement of Science. Electronics, January 1936, page 10.

Society Sets Standards for Aerial Photography. Brief reference to the fact that the American Society of Photogrammetry has issued standard specifications for aerial photography and for aerial photographs for stereoscopic plotting of contour maps. Industrial Standardization, February 1936, page 36.

Motion Pictures in the Army Air Corps. An outline of the extensive aerial motion-picture activity now being carried out in the departments of the Air Corps. The relation between the various Air Corps units is explained, and the many uses to which motion pictures are put in instruction and training, technical studies, maintenance and inspection of aircraft are described. Difficulties in photographing formations or single airplanes and in the operation of cameras in cold weather are reviewed, and the important part motion-picture photography will play in future military observation operations is discussed. Journal of the Society of Motion Picture Engineers, February 1936, page 183.

Radio

Graphical Harmonic Analysis. J. A. Hutchinson. The method described is applicable to waves of the type wherever there are present sine components of odd harmonies and cosine components of even harmonics, as for amplifiers or modulators. Electronics, January 1936, page 16.

An Interesting Use of Ultra-High-Frequency Radio in a Meteorological Study. A. A. McKenzie. Application of ultra-high-frequency radio for the transmission of time signals and for communication between observation points in a recent study of the winds in the vicinity of Mount Washington, N. H. Bulletin of the American Meteorological Society, December 1935, page 317.

On the Advent of Radiaura. C. G. Grey. General discussion of the need for an airplane radio receiving apparatus which would indicate approximately the direction and distance of any airplane within a given distance. Attempts to produce such an apparatus in England are referred to. Aeroplane, January 15, 1936, page 65.

Oscillograph Amplifiers for Very Wide Frequency Ranges. M. von Ardenne. Discussion of the special requirements of amplifiers for increasing the sensitivity of cathode-ray oscillographs, and a description of the design, construction and properties of a special amplifier. Wireless Engineer, February 1936, page 59.

Radio and Air Traffic. H. A. Taylor. Discussion of direction finding and its applications, homing equipment, and radio beacons, traffic control, and blind landing methods, with reference to the American standardized blind approach system and the German Lorenz system. Flight, January 30, 1936, page 120.

Radio Communication. H. de Bellescize. Concluding article which deals with atmospheric variations in radio communication. An analysis is given of the current produced in a receiver by the atmospheric conditions. The effect of seasonal variations of the atmospheric level on long wave, atmospheric levels based on the characteristics of reception, and the influence of hour, season, and location of the receiver are discussed. L'Onde Electrique, November 1935, page 740.

Radio-Meteorographs. K. O. Lange. Continuation of an article describing other radio-meteorographs operating on the Olland principle. The radio-meteorographs developed in France by R. Bureau, and the Duckert and Väisälä radio-meteorographs of variable frequency are discussed. Bulletin of the American Meteorological Society, December 1935, page 297.

APPARATUS

The Compensated Thermocouple Ammeter. W. N. Goodwin. A general solution to the problem of determining temperature and heat distribution in conductors. The development of the theory of the electrothermic ammeter of the thermocouple types, together with its compensation features, is also given and practical applications of the theory are presented. Electrical Engineering, January 1936, page 23.

Radio Compass. Description of a new visual-indicator radio compass for aircraft which has been developed by the Bell Laboratories. The compass consists of an adjustable-loop antenna, a non-directional antenna, and a compass control unit. It has been designed for use with the Western Electric 17-A receiver, a light two-band set for private plane use. Aviation, February 1936, page 50.

New Aviation Radio Receives 2 Signals on Same Frequency. Brief reference to a new radio device under test in Pittsburgh by means of which directional signals operate a needle pointer on the instrument board and voice signals are received in headphones. Science News Letter, January 25, 1936, page 52.

The Radio Sounding Balloons. M. Victor. Description of the radio equipment developed by the French National Meteorological Office for small balloons. The short-wave radio automatically signals the temperature encountered by the balloon in ascents into the stratosphere. Les Ailes, January 9, 1936, page 4.

A Tube-Controlled Motor. P. B. King, Jr. Details of a synchronous motor which, with electronic connection between field coils, forms a mechanically coupled variable-frequency oscillator. Electronics, January 1936, page 14.

Navigation

Calculation of an Astronomical Point — Bastide-Lepetit No. 300. Description of the Bastide method for airplane navigation. This is a mechanical-graphical method utilizing two systems of graphic designs on transparent strips, one which is convenient for calculating the position from any heavenly body, and used especially for the sun, and the other only for stars. La Technique Aeronautique, No. 138, 1935, page 297.

Instrument Flying "A B Initio." S. A. Dalbro. Results of experiences in instrument flying which were gained at the flying school of the Royal Danish Naval Air Service. Flight, January 9, 1935, page 52.

Meteorology

The New Weather Science. W. H. Wenstrom. One of a series of articles on the subject of flying weather. The underlying principles of air-mass-and-front analysis are explained and some fundamental relations in the general physics of the atmosphere are examined. Stratus, cumulus, nimbus, and cirrus clouds are described. Aero Digest, February 1936, page 20.

Air Fountains. Brief description of the action of an airplane on encountering an air fountain or uprushing columns of air, such as are especially well developed on clear summer days over dry hot ground. Abstract from newspaper account. Bulletin of the American Meteorological Society, December 1935, page 323.

Airships in Gusty Weather May Face Downward Accelerations Equal to 1/3 that of Gravity. A. M. Kuethe. Brief discussion of results obtained in a study of the effect of cold air masses moving down from Arctic Canada, and interacting with warmer ones coming north from the tropics, thus making the weather of the temperate zones. Abstract from Science Service. Bulletin of the American Meteorological Society, December 1935, page 323.

An Attempt to Make a Synoptic Interpretation of an Atmospheric "Sounding" During a Parachute Jump. V. Dejorjio. A picture is given of the air-mass structure over the Northern Caucausus during a parachute jump shortly after a sudden squall with heavy rain started at the airport. Abstract from Meteorological Messenger, 1932, No. 1-2, page 1. Bulletin of the American Meteorological Society, December 1935, page 323.

Dispersal of Thin Cloud or Fog Apparently by the Air-Mixing Action of an Airplane. Very brief abstracts from Meteorological Magazine, July and November, 1935, pages 140, 141, and 232, which describe three incidences. Bulletin of the American Meteorological Society, December 1935, page 320.

Lightning Hazards to Aircraft Operation. J. C. Franklin. Abstract of Air Commerce Bulletin pages 138–140, discussing the chances of lightning striking an airplane and giving some recommendations. Bulletin of the American Meteorological Society, December 1935, page 322.

A Three-Dimensional Weather-Map Device. I. I. Zellon. Description of a method of mapping which was devised as a means to facilitate the representation of upper air data on the same map with surface data. Bulletin of the American Meteorological Society, December 1935, page 295.

Air Forces

FRANCE

The Participation of the Government in the Development of Standard Types of Airplanes. Outline of the present set-up in the French Air Ministry for the experimental development of standard military types of airplanes, with suggestions for improvements. A report on the efforts of the Government from 1928 to 1933 in developing new airplane and seaplane types is included with illustrations of some military planes. Revue de l'Armee de l'Air, December 1935, page 1365.

Events Abroad (France). Among other subjects, reference is made to new equipment for the French Naval Service, with brief mention of an experimental plane with a variable wing area. Royal Air Force Quarterly, January 1936, page 123.

GREAT BRITAIN

The Accident Rate of British Military Aircraft. Editorial on the recently published accident returns of the Royal Air Force for 1935. Comments are given on the skill of the aviators and dependability of British military aircraft and engines. Statistics are quoted and compared with those of previous years, and the hazardous conditions of foreign service are pointed out. Engineering, January 24, 1936, page 98.

The Engineering Outlook—Aircraft. Discussion of the rapid growth of the British aircraft industry with particular reference to and statistics for the Royal Air Force expansion since 1922, and with predictions for the number of planes the Force will require in 1935–36 and 1936–37. Growth in the demand for civil planes from 1925 to September 30, 1935, is also taken up. Engineering, January 24, 1936, page 100.

Technical Maintenance of the R. A. F. Rejoinder to a previous article advocating an engineering branch for the R. A. F. The author describes the best type of engineer officer as a maintenance engineer, rather than a design engineer, and recommends this type for the majority of engineer officers with a very small quota of highly qualified officers. Royal Air Force Quarterly, January 1936, page 16.

The Big Bomber of Today. Discussion of the possibility of converting air liners into bombers in time of war, and a review of the new foreign bombers. References is made to U. S. bombers, the British position in the design of bombers, and French and Italian models. Illustrations include British, French, German, and Italian as well as U. S. bombers. Flight, January 9, 1936, page 32.

Air Warfare

Do We Wish to Attack Ships from the Air? Captain E. Beltramo. Discussion of the possibility of attacking ships at sea by means of special bombers. The defense of ships against aerial attacks and the development of anti-aircraft guns are reviewed. Two methods for attacking ships from the air are compared, namely, attack from high altitudes with heavy bombers flying in compact formation, and attack from low altitudes by single airplanes of high speed and maneuverability, and dropping torpedoes and bombs. The author prefers the second method and describes the characteristics necessary for airplanes for such attack, for firing in a dive, and for dropping torpedoes and bombs from low altitudes. Rivista Aeronautica, January 1936, page 33.

Fundamentals of Aerial Combat. V. Kusniescioff. Long discussion in two articles on the possibility of firing and dropping bombs in an aerial combat between pursuit planes and bombers. Formulas are given for evaluating the effectiveness of aerial firing, and the armament and instruments required for a pursuit plane are described. Diagrams are used to illustrate an attack of pursuit squadrons against groups of heavy bombers. From Corniere della Flotta Aerea, June and July 1935. Rivista Aeronautica, January 1936, page 53.

The Possibilities of the Very Large Bombers. P. Desbordes. Advantages of very large bombers over a number of smaller planes in warfare. Les Ailes, January 2, 1936, page 7.

Problems of Air Warfare. G. W. Feuchter. Review of book discussing the problems which face countries building up modern air forces today. The author believes that the most useful military plane of the future will be the multi-seater fighter with speed range and ceiling almost identical with those of the single-seater fighter, and that, as the margin of superiority between the fighter and bomber will shortly be practically nil, the fighter will become nothing more than a home defensive weapon. He takes up four methods of bomber attacks which are not original and describes new methods of attack of bombers by fighters called "salvo bombing." Royal Air Force Quarterly, January 1936, page 135.

Aircraft Industry

Safer Flying. Bureau of Air Commerce statistics for first half of 1935 in regard to mileage, passengers, and accidents, and a brief comparison with other years. Airport statistics as of January 1, are given on page 70, and pilot statistics as of January 1, on page 74. Aero Digest, February 1936, page 72.

British Aviation in 1935. Review of technical progress in the British aircraft industry with reference to the adoption of civil design to military requirements, engine developments, the problem of maintaining power at great heights, robustness and reliability of aircraft and engines, and commercial aspects. Engineering, January 17, 1936, page 74.

Progress in 1935. G. Houard. Review of French aviation in 1935 including developments in the air force, aviation policies, aeronautical industry, private aviation, and records. Les Ailes, January 2, 1936, page 13.

Airports

Architecture of the Airport. J. Dower. Trend of design today as disclosed by some of the buildings under construction or in process of design in England and other countries. Flight, January 30, 1936, page 100.

Physiology

Body Mechanism and Energy. A. V. Hill, M.D. The article includes paragraphs on heat production of muscle, oxygen consumption as a measure of energy, mechanical efficiency (which is less than 25 per cent), and horsepower developed by man (1.6 hp. momentously). Engineer, December 6 and 13, 1935, pages 599 and 623.

The Human Resistance to Speed. M. J. Richou. Results of experiments to determine how the pilot is affected by high speeds and by climbing toward the stratosphere. It was found that a pilot weighing 70 kg. and flying at 500 km. per hr. on a curve of 200-meter radius, exerts a pressure of nearly 800 kg. on his chair. The author recommends that the maximum speed be reached progressively and that the line of flight be as rectilinear as possible. Les Ailes, January 9, 1936, page 7.